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ORIGINAL ARTICLES.

I.—Some Suggestions on Extinction.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

THE sudden disappearance of groups of animals, which have existed through long periods of time and have attained a high degree of specialization, is a phenomenon of which many instances will occur to every student of Palæozoology. For instance, to mention only two cases in illustration, we may refer to the disappearance of the Dinosaurs at the end of the Secondary period, and that of the North American Titanotheres in the Miocene. Of the proximate causes of this extinction little is known: they must have been either inherent in the organisms themselves, or have been connected with the relations of the organisms with their environment; probably in every case several factors co-operated to bring about the observed result. In a recent paper by Mr. C. B. Crampton (Proc. Roy. Phys. Soc. Edinburgh, vol. xiv, p. 461) a possible inherent cause of extinction is suggested. It is impossible to do justice to this interesting paper in a short note, but the gist of the argument seems to be as follows:—In the original unicellular organism the possibilities of variation are almost infinite, but as soon as evolution along any line begins, these possibilities are restricted, and become more and more so the more highly specialized the animal is; in short, the potential variation of an organism becomes less and less as specialization advances. Furthermore, under the influence of natural selection, in each generation the individuals which tend to vary in the same direction will survive, while at the same time, as already pointed out, their capacity for variation becomes more and more restricted. The consequence of this will be that the more highly specialized any stock becomes, the more the individuals composing it will come to resemble one another, until at length the same results as arise from close interbreeding, viz., weakening of the stock and, finally, extinction, may follow.

In a paper recently read before the Zoological Society, the present writer, in speaking of the evolution of the Proboscidea, took the opportunity of pointing out another possible cause of extinction of some groups of animals. It will be observed that in many cases the evolution of a group of animals is accompanied by a simultaneous increase in the bulk of the individuals composing it. The Proboscidea themselves offer a fairly good instance of this tendency, but a better known case is that of the horses. An almost necessary corollary of this increase in bulk is the lengthening of the individual life, or at least what, for our argument, amounts to much the same thing, the lengthening of the time taken to attain sexual maturity. In many Ungulates this increased longevity is indicated by various modifications of the teeth, tending to give them a longer period of wear: generally this end is attained by the increasing hypselodonty of the cheek-teeth. A necessary consequence of the longer individual life will be that in a given period fewer generations will succeed one another, and the rate of evolution of the stock will therefore be lowered in the same proportion. If now the conditions of life undergo change, the question whether a given group of animals will survive or become extinct will depend upon whether it can undergo sufficiently rapid variation to enable it to avoid getting so far out of harmony with its surroundings that further existence becomes impossible. It seems to follow then that the smaller animals, in which the generations succeed one another rapidly, will have a better chance of surviving than the larger and more slowly breeding forms, which at the same time will be still further handicapped if, as is usually the case, they are more highly specialized than the smaller forms, and therefore have a more restricted range of possible variation.

Another result of the increased length of the individual life would be that, during the earlier history of a stock the modification undergone by its members would be more rapid than among the later forms, a phenomenon of which actual instances might be cited, e.g. in the Proboscidea. On the same principle it may perhaps also be explained why certain groups have remained comparatively unchanged through long periods of time. The Sirenia may be a case in point, though no doubt in this case, among other factors, the comparative stability of the conditions of life has had much to do with the conservative character of the group.

II.—WOODWARDIAN MUSEUM NOTES: ON SOME WENLOCK SPECIES OF *LICHAS*.

By F. R. COWPER REED, M.A., F.G.S.

(PLATE I.)

THE entire collection of Wenlock fossils made by T. W. Fletcher, Esq., which is now in the Woodwardian Museum, affords unsurpassed facilities for studying the material on which a large number of species of trilobites were founded. Particularly is this the case with those of the genus *Lichas*, and a recent examination of the types and other specimens which Fletcher used in writing his paper "Observations on Dudley Trilobites" (Q.J.G.S., 1850, vol. vi, pp. 235–239, pls. xxvii and xxvii *bis*) has led me to make the following notes upon them. I have also had the privilege, through the kindness of Dr. Arthur Smith Woodward, F.R.S., of examining the specimens in the British Museum (Nat. Hist.), Cromwell Road.

LICHAS (CORYDOCEPHALUS) ANGLICUS (Beyrich). (Pl. I, Figs. 1, 2.)

Lichas Bucklandi, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 235, pl. xxvii, figs. 2, 3, 4, ? 5, 5*a* (*non* figs. 1, 1*a*); pl. xxvii *bis*, figs. 1, 1*a*, 1*b*.

There is considerable variation in the degree of development of the spines on the pygidial margin of this species. A similar variation is noticeable in *Cheirurus bimucronatus* and the species of *Acidaspis* from the same beds. The relative length of the axis of the pygidium also shows marked individual differences. Fletcher figured one specimen (*op. cit.*, pl. xxvii, figs. 5, 5*a*) which he described as a young individual, and probably it should be regarded as such. But there are two well-marked and constant varieties which show definite features separating them from the type-form, and in fact are more abundant than the latter.

(i) The first variety, which may be called *wenlockensis* (Pl. I, Fig. 1), has a pygidium which is subquadrate in outline, and has almost a straight posterior border. The nine marginal spines are unequally developed; the first two pairs are strong and of equal size, but the third pair, situated at the lateral corners of the posterior margin, are much stouter and larger, projecting nearly straight backwards behind the pygidium. Between them lie three equidistant smaller spines, the median one of which is generally the largest. Minute prickles are in some specimens noticeable along the margin between the spines. A shallow groove parallel to the posterior edge of the pygidium and marking off a distinct border, but not crossing the post-axial median piece, is present on the lateral lobes behind the second pair of pleuræ. A similar though fainter groove is distinguishable on the pygidium of the type-specimen and type-form figured by Fletcher (*op. cit.*, pl. xxvii *bis*, figs. 1, 1*a*), and in the other specimen regarded by him as a young individual (pl. xxvii, figs. 5, 5*a*), but no mention of it is made in his description.

The posterior half of each of the two pairs of pleuræ behind the pleural furrow in the variety *wenlockensis* is also remarkably narrow in comparison with the anterior portion. In Fletcher's figure of the type-form the posterior portion is made broader than it is in reality in the specimen.

From the above remarks it will be seen that the distinguishing features of this variety are the general shape of the pygidium and the development of the lateral spines. The thorax and head-shield in complete specimens show no points of difference from the type-form which can be established as constant.

(ii) The second variety (Pl. I, Fig. 2), of which there are also complete specimens in the Woodwardian Museum, likewise exhibits its distinctive features only in the pygidium. In this form there are only eight marginal spines, the posterior median one being absent or merely represented by a small prickle. The shape of the pygidium is subquadrate rather than semicircular; the first two pairs of lateral spines (i.e. the pleural points) are moderately developed, and equal or subequal in size; the third pair of spines is developed as in the variety *wenlockensis*, being stronger and stouter than the others; the fourth pair of spines is reduced in size, and slender, and usually rather closely placed to the third pair, leaving the median portion of the posterior margin free of spines and only armed with small prickles. In other respects this variety resembles that above described. Both differ from the type-form by the subquadrate rather than semicircular shape of the pygidium, and by the specially strong development of the third pair of marginal spines. This second variety may be termed *obtusicaudatus*.

Salter attributed both these varieties of *L. anglicus* to *L. hirsutus*, as his labels and Catalogue show (Cat. Camb. Sil. Foss. Woodw. Mus., p. 130, *a* 961, *a* 963, *a* 964), but they differ completely from it, as a reference to Fletcher's figured specimens and the descriptions of that species at once proves.

The 'angularity' of the head-shield upon which Fletcher remarks in one specimen (figs. 3, 3*a*, pl. xxvii) is caused by the sudden bend in the front margin of the free cheek, just outside the point where the facial suture cuts the border. This projection of the middle portion of the head-shield is very well marked in some specimens of the type-form and in the variety *wenlockensis*, and is indicated in the restoration of the front border by Fletcher (*op. cit.*, pl. xxvii *bis*, fig. 1*a*). It appears to be a characteristic and constant feature, being noticeable wherever that portion of the head-shield is preserved.

LICHAS (CORYDOCEPHALUS) HIRSUTUS (Fletcher). (Pl. I, Figs. 3, 4, 5.)

L. hirsutus, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 236, pl. xxvii, figs. 6, 6*a*; pl. xxvii *bis*, figs. 2, 2*a* (*non* pl. xxvii, figs. 7, 7*a*).
L. Bucklandi, Fletcher (*pars*): ibid., pl. xxvii, figs. 1, 1*a*, 1*b* (*non cet.*).

There are three specimens ascribed to this species by Fletcher and figured by him, all of which are in the Woodwardian Museum. Excluding the remarks on the specimen figured on pl. xxvii, figs. 7, 7*a*, the description of the species given by Fletcher is fairly accurate and complete so far as it goes, but the figures (pl. xxvii, figs. 6, 6*a*; pl. xxvii *bis*, figs. 2, 2*a*) show such differences that they might be thought to represent distinct species. The specimens, however, from which these figures were drawn are in reality closely similar, and do not exhibit more than the customary amount of variation. The specimen on which figs. 6, 6*a*, pl. xxvii were founded is so imperfect that it shows Fletcher used other specimens together with it in order to draw up his description of the species. There is no distinctly raised border round the pygidium, the appearance in Fletcher's figured specimen (pl. xxvii, fig. 6*a*) being due to unequal crushing. Other specimens show that the relative length of the axis slightly varies, and also the number of tubercular rings upon it.

A well-preserved complete specimen in the Woodwardian Museum showing head, thorax, and pygidium attached, and several other less perfect specimens, enable me to give a complete description of the species, and render possible the identification of isolated head-shields, previously of doubtful specific position.

Diagnosis.—Head-shield broadly parabolic, more than twice as broad as long, swollen centrally, bent down at sides and strongly in front. Glabella elevated, convex, large, broader than long; greatest width across middle third. Central lobe long, subcylindrical with parallel sides between anterior bicomposite lateral lobes, slightly expanded in front, embracing front end of these lobes; defined posteriorly by strong curved transverse furrow at level of second lateral furrow. Anterior lateral lobes rather swollen, oval but slightly pointed behind; each as broad as central lobe; extend three-fourths the length of the glabella; are defined externally by strong furrow. Middle and basal lobes obsolete, their place being occupied by a subtriangular, uniformly swollen surface, not differentiated or marked off from the fixed cheek, except behind the eye, where the posterior portion of the axal furrow is faintly developed.

Between the central lobe and neck-ring is a narrow post-central lobe depressed below the level of the central and lateral lobes, and defined laterally by the weak backward continuation of the first lateral furrows to the neck-ring; three conspicuous large isolated tubercles usually ornament it.

First lateral furrows curve inwards strongly from anterior point of origin, sweeping round front end of anterior lateral lobes; then run backwards to transverse furrow with increasing strength and almost parallel to each other, behind which they diverge and are feebly continued to neck-ring.

Axal furrows strong, curved outwards, defining outer border of anterior lateral lobes; not continued behind second lateral furrows, which at level of eyes pass imperceptibly into them. Close to the neck-ring a faint furrow on each side represents the posterior portion of the axal furrows.

Second lateral furrows form a continuation inwards of the axal furrows round the base of the anterior lateral lobes, joining first lateral furrows at angle of 75°–90°. Transverse central furrow runs across middle of glabella as continuation of second lateral furrows with equal strength, but with independent backward curvature. Occipital ring arched forwards, swollen, broadest in middle, generally with median tubercle.

Fixed cheeks triangular, swollen towards inner portion, not marked off in middle from glabella; posterior edge straight, horizontal at right angles to axis of glabella, but bending sharply forward at outer angle at about 130°. Eye-lobe moderate, prominent, horizontal, at level of second lateral furrow. Neck-ring on posterior margin elevated, narrow, ornamented with single row of large tubercles.

Facial suture makes a sharp bend outwards behind eye, curving thence backwards to cut lateral margin behind spine.

Free cheek narrow, elongated, triangular, inner portion swollen, bearing prominent elevated eye of moderate size. Middle of lateral margin furnished with strong short outwardly projecting spine, curving slightly backwards.

Head-shield in all parts (including spines) ornamented with large tubercles, not closely set, with smaller ones interspersed.

Thorax composed of eleven segments. Axis moderately convex, nearly as wide as pleural portions, cylindrical for first six or seven rings, then tapering gradually backwards to pygidium. Axal furrows well-marked. Axial rings narrow, rounded, with narrow articulating band.

Pleuræ narrow, rounded, cylindrical, with free pointed extremities; horizontally extended to fulcrum, which is situated at about half their length, then bent downwards and slightly backwards. Narrow flattened band on front edge. Each thoracic segment bears a single row of a few large equally-spaced tubercles.

Pygidium broadly parabolic, usually slightly broader than long. Axis convex, subcylindrical or slightly tapering, bluntly rounded at posterior end; extends about two-thirds the length of pygidium, and occupies about the middle third of width. One strong complete axial ring at front end with narrow articulating band on front edge, followed by 3–5 narrow transverse rows of tubercles in middle portion of axis; the first one or two rows are separated by more or less distinct furrows. Posterior end of axis abrupt, blunt, not circumscribed by furrow, but continued posteriorly by narrow, depressed, tapering post-axial median piece, which becomes parallel-sided and extends to posterior border between third pair of marginal spines.

Lateral lobes flattened, slightly bent down, with three pairs of large spines projecting beyond the margin and numerous minute spinules or prickles. Two pairs of well-defined pleuræ curving backwards; each pleura marked by median furrow dividing it into two unequal portions, of which the posterior is the narrower and more elevated. Each pleura is produced beyond pygidial margin into short free point, forming thus the two anterior pairs of marginal spines, which also bear small lateral prickles (only occasionally preserved). Pleuræ separated by well-marked interpleural furrows curving backwards, of which the first makes an angle of about 30° with the front margin, and the second makes an angle of about 60°–70° with the same. Between the second pleuræ and the post-axial piece is a triangular, irregularly tuberculated area on each side with no furrow upon it. The posterior pair of spines are approximate and directed straight backwards, and are generally about equal in length to the second pair, from which they are removed by about twice the distance that they are from each other.

MEASUREMENTS.

	mm.
Length of trilobite	21·0
Length of head-shield	6·5
Width of head-shield (from tips of genal spines)	18·0
Length of thorax	7·5
Length of pygidium...	7·0
Width of pygidium	9·0

REMARKS.—The head-shield shows considerable resemblance to that of *L. anglicus* (Beyr.); but the latter may be distinguished by (1) the more quadrato-oval shape of the anterior lateral bicomposite lobes of the glabella, owing to the second lateral furrow meeting the first lateral furrow at a right angle, (2) the greater size of the post-central lobe of the glabella, (3) the small outward bend in the first lateral furrows in the middle of the central lobe, (4) the absence of the basal portion of the axal furrow, (5) the smaller lateral expansion of the anterior end of the central lobe of the glabella, (6) the different shape of the free cheek, and (7) the regular curve described by the posterior margin of the head-shield. A comparison of Fletcher's figure (pl. xxvii *bis*, fig. 1*a*) of *L. anglicus* plainly shows the points of difference.

The glabella in *L. anglicus* is also generally of rather less width, but is somewhat longer; and the head-shield is not so bent down in front, nor so swollen centrally.

In the pygidium we see in *L. hirsutus* much resemblance to *L. Haueri* (Barr.),[1] and the head-shield, with the exception of the transverse post-central furrow, is likewise somewhat similar. The peculiar laterally angulated outline of the posterior margin of the head-shield and position of the spine on the free cheek is likewise met with in *L. Haueri* and in other Bohemian species.

The head-shield referred by Fletcher to *L. anglicus* (pl. xxvii, figs. 1, 1*a*, 1*b*), but mentioned as being of a slightly unusual form (p. 236), should be attributed to *L. hirsutus*, with which it agrees in all essential features.

Barrande (*op. cit.*, p. 602) considered that *L. hirsutus*, Fletcher, was identical with his *L. palmata* (Barrande, *op. cit.*, p. 599, pl. xxix, figs. 1–13), but remarks that one of Fletcher's specimens (shown in fig. 5, pl. xxvii, Q.J.G.S., 1850, vol. vi) represents a different form to which the specific name *L. hirsutus* must be restricted. Probably Barrande meant fig. 7 instead of fig. 5, for the latter is attributed by Fletcher to *L. Bucklandi* in his explanation of plate xxvii. *L. hirsutus*, Fletcher (excluding fig. 7, pl. xxvii), however, differs from *L. palmata* in numerous points, the most important of which are the absence of the well-defined middle glabellar and occipital lobes, and in the pygidium the presence of only one strong axial ring followed by several incomplete rows of tubercles. These features are amply sufficient to separate it specifically.

LICHAS (CORYDOCEPHALUS) HIRSUTUS, var. TUBERCULATUS (var. nov.).

(Pl. I, Fig. 6.)

Several specimens of a *Lichas* from the Wenlock Limestone or Shale of Dudley show points of difference from the type-form of *L. hirsutus* almost sufficient to constitute a distinct species. In the head-shield the basal portion of the axal furrows is wanting, and the fixed cheeks are completely confluent with the middle lateral portions of the glabella; there is one conspicuously large tubercle on the middle of the fixed cheek, and the eye-lobe projects laterally in a very prominent manner; the occipital ring also bears a large

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[1] Barrande: Syst. Sil. Bohem., vol. i, p. 604, pl. xxviii, figs. 38–44.

median tubercle. There are only ten segments recognizable in the thorax in the one complete specimen which I have examined, but this probably only indicates immaturity. The pygidium has a large prominent central tubercle near its posterior end; the transverse rows of tubercles on the axis behind the first ring are very indistinct; the post-axial piece is very short and ill-defined. The two pairs of pleuræ have their free ends more elongated than is usual, the second pair indeed projecting back behind the posterior end of the pygidium and behind the third pair of spines, which are very short and blunt.

Fletcher labelled one of these specimens *L. Bucklandi* (= *L. anglicus*), but Salter labelled another (*a* 963) *L. hirsutus*. From the presence of several specially large tubercles this variety may be termed *tuberculatus*.

LICHAS (CORYDOCEPHALUS), sp.

L. hirsutus (Fletcher), "young": Q.J.G.S., 1850, vol. vi, pl. xxvii, figs. 7, 7*a*.

The pygidium figured by Fletcher as belonging to a young individual of *L. hirsutus*, "from the great similarity in the arrangement of the tubercles on the axis and sides," shows such important differences that it does not seem possible to regard them as merely marking a stage of growth in an individual of this species. The pygidium is semicircular, with three pairs of marginal spines of subequal size. The axis is very broad, blunt, and subconical, reaching fully three-fourths the entire length of the pygidium, and occupying considerably more than its middle third. There is one strong ring at the front end of the axis, followed by two or three much narrower and fainter rings marked by tubercles. There is no distinct post-axial piece. The axal furrows are strong and deep. There are two pairs of pleuræ on each side (not three 'ribs' as Fletcher states), curved backwards, and ending in short stout, backwardly directed free points on the margin. The surface of each pleura is divided down the centre by a strong median furrow, equal in strength to the interpleural furrows; the anterior and posterior parts of each pleura are of equal size and elevation, and each is ornamented by a single row of large tubercles. The posterior pair of spines is rather shorter than the first and second pairs, and its members are twice as closely approximated to each other as they are to the second pair of spines. A few large tubercles are somewhat regularly disposed on the axis and the portions of the lateral lobes behind the second pleuræ.

The margin is strongly and sharply incurved below, and is marked by concentric raised striæ, which also cross the under-surface of the spines.

MEASUREMENTS.

	mm.
Length of pygidium	4
Width of pygidium	7
Width of axis	3

REMARKS.—It is possible that the specimen above described belongs to an immature individual of some species, though probably not to *L. hirsutus*. It is advisable, therefore, in the absence of further evidence to leave it unassociated with any of the described species, and to refrain from considering it a new species.

LICHAS (DICRANOPELTIS) WOODWARDI, sp. nov.[1] (Pl. I, Figs. 7, 8.)

L. Barrandii, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 238, pl. xxvii, fig. 10 (*non* pl. xxvii *bis*, fig. 5).

The description which Fletcher gave of the species which he called *L. Barrandii* corresponds exactly with his fig. 5, pl. xxvii *bis*, and with the two specimens on which this was founded, but it does not at all agree with the figure on the preceding plate (fig. 10, pl. xxvii), nor with the specimen which it represents, and the only point in the description which is borrowed from it refers to the concentric striation of the under side, which is not seen on the other specimens. A suspicion that two species have been confounded at once arises, and an examination of the type-specimens which are in the Woodwardian Museum confirms it. Moreover, the type-specimen represented in fig. 10, pl. xxvii shows only the inner surface of the shell, but another showing the actual outer surface in relief has come into our possession with the remainder of Fletcher's collection presented in 1897, and it was labelled by Fletcher himself *L. Barrandii*. From this material a fairly complete description of this new species can be given, so far as the pygidial characters are concerned.

Pygidium broadly parabolic; ratio of length to width as 3 : 4. Axis rounded, convex, slightly elevated above side-lobes; nearly one-third the width of the pygidium at front end; short, broad, not as long as broad; sides converge posteriorly at angle of about 35°; abruptly truncated at posterior end by straight transverse furrow; bears two well-marked continuous rings at anterior end. Axal furrows well-marked, nearly straight. Transverse furrow defining termination of axis weak in centre, strongly impressed at sides.

Lateral lobes flattened, nearly horizontally extended, furnished with six pairs of furrows of equal strength; each lobe consisting of three broad foliaceous pleuræ with free falcate, backwardly directed ends. First two pleuræ on each side complete, and well-defined by strong interpleural furrows of equal depth, the first furrow making an angle of about 30° with the front edge of the pygidium, and the second an angle of about 60°. First pleura marked by diagonal furrow which runs parallel to the first interpleural furrow, but dies out before reaching the free point of the pleura. Second pleura marked by similar furrow starting from axal furrow at the point of origin of first interpleural furrow, and running thence parallel to second interpleural furrow, but dying out before reaching free point.

Axal furrows continued backwards behind axis, at first with same angle of convergence and then almost parallel to each other, but disappearing at some distance from the posterior margin of pygidium. The post-axial median piece enclosed between them is narrow, and slopes down rapidly to level of side-lobes. Third pair of pleuræ between second pair of pleuræ and post-axial median piece; each third pleura ends in backwardly directed free point, and is crossed by diagonal furrow making an angle of about 80°–90° with front edge of pygidium. Free points of third pair of pleuræ approximate (not well preserved); margin of pygidium incurved, and shows on under-surface concentric equidistant raised thread-like lines.

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[1] This species is mentioned by the author in his paper on the genus *Lichas*: Q.J.G.S., 1902, vol. lviii, pp. 72 and 82.

Ornamentation consists of large round tubercles of two or three graduated sizes, not very closely set. Owing to the breaking off of the heads of the larger tubercles (which are hollow), circular pits with a raised margin are left as cicatrices.

MEASUREMENTS.

	I (Fletcher's figured specimen).	II.
Length of pygidium	? ...	c. 31 mm.
Width of pygidium	46 mm. ...	40 ,,
Width of axis at front end	15 ,, ...	13·5 ,,
Length of axis	11 ,, ...	9·0 ,,

REMARKS.—This species differs from *L. Barrandii* (Q.J.G.S., 1850, vol. vi, pl. xxvii *bis*, fig. 5) by the following features: (1) greater relative length of pygidium, (2) narrower and shorter axis, (3) only two axial rings, (4) no axial tubercle, (5) straight transverse posterior furrow defining end of axis, (6) longer post-axial median piece, (7) less backwardly curved pleuræ, (8) course of furrows on lateral lobes, (9) coarser tuberculation.

The pygidium of *L. scaber* (Beyr.) bears a considerable resemblance to that of *L. Woodwardi*. It may also be mentioned that the ornamentation of *L. Grayi*, of which only the head-shield is known from the Wenlock Limestone, is somewhat similar.

LICHAS (DICRANOPELTIS) BARRANDEI, Fletcher (emend.).

Lichas Barrandii, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 238, pl. xxvii *bis*, fig. 5 (*non* pl. xxvii, fig. 10).

Fletcher's diagnosis of this species, with the exception of the statement that "the incurved under-portion is concentrically striated," which cannot be verified with our present material, applies to fig. 5, pl. xxvii *bis*, and does not need any amplification. It may, however, be remarked that the figure is partly a restoration based on two nearly complete specimens (*b* 28, *b* 29 in Salter's Catalogue), the measurements of which are as follows:—

	I (*b* 29).	II (*b* 28).
Length of pygidium	20 mm. ...	18 mm.
Width (at front end) of pygidium ...	? ...	24 ,,
Width of axis (at front end)	13 ,, ...	11 ,,
Length of axis...	10 ,, ...	?

It is unfortunate that of this species only the pygidium is known at present. In one of the specimens (I) a faint transverse furrow, incomplete in the middle, defines the posterior end of the axis, recalling the much stronger furrow seen in *L. Woodwardi*. Fletcher does not mention it, and it appears to be obsolete in the better preserved specimen (II), which he used chiefly in drawing fig. 5, pl. xxvii *bis*.

LICHAS (DICRANOPELTIS ?) SALTERI, Fletcher.

L. Salteri, Fletcher: Q.J.G.S., 1850, vol. vi, p. 237, pl. xxvii, figs. 9, 9*a*; pl. xxvii *bis*, fig. 4.

Lindström[1] records this species from Gotland, and believes that *L. laticeps*, Angelin (Pal. Scan., 1854, pp. 70, 72, t. xxxvii, figs. 8, 8*a*, *non* t. xxxviii, fig. 5), and *L. gibbus*, Angelin (Pal. Scan., p. 71, t. xxxvii, fig. 1, pygidium only), are synonyms. The rows of large tubercles on the glabella and side-lobes are held by Lindström to be the particular characteristic of the species; and unfortunately no part but the head-shield, and that incomplete, is known from the Wenlock Limestone. It is impossible to feel on safe ground in assigning any of the isolated pygidia of this horizon to *L. Salteri*, but Lindström[2] considers the pygidium figured by Angelin (*op. cit. sup.*) as *L. gibbus* as probably belonging to this species, and describes it as possessing a linear axis narrowing posteriorly, furnished with about eleven segments, of which the posterior ones are inconspicuous; a narrow prolongation extends behind it towards the margin. Three small pleura-like ribs are given off on each side from rather in front of the middle of the axis. There is a raised border round the pygidium, and from it short, backwardly directed spines project near the terminations of the ribs. Between the two posterior ones are three pairs of small spines, one of which projects from the axis. It is to be regretted that Lindström did not give a figure of this specimen, as Angelin's figure leaves much to be desired, and it is difficult to form an adequate idea of the pygidial characters from the description.

The old generic designation *Trochurus* is revived by Lindström for this species, and applied also to *T. pusillus*, Angelin, and *T. Bucklandi*, Milne Edwards (= *L. anglicus*, Beyrich). Beyrich, however, in 1846 (Untersuch. über Trilob.) declared that this name, which he had instituted in 1845 (Ueber Boh. Trilob., p. 31, fig. 14), should be allowed to drop, as the genus had been founded on a specimen consisting of portions of two distinct trilobites (i.e. a head of *Staurocephalus Murchisoni* combined with a pygidium of *L. speciosus*, Beyr. [= *L. palmata*, Barrande]). Barrande (Syst. Sil. Boh., vol. i, p. 603) points out this fact, and also rejects for this reason the specific name *L. speciosus*, which Beyrich had given in 1845 to the composite form. It accordingly appears inadvisable to revive the name *Trochurus* under any form. Beyrich himself employed in 1846 Goldfuss' earlier name *Arges* (1839) for his species *L. speciosus* (= *L. palmata*, Barr.), but, as previously pointed out by the present writer,[3] this name is preoccupied.

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[1] Lindström: Gotl. Silur. Crust. Öfv. K. Vet. Akad. Forhandl., 1885, No. 6, p. 60 (*Trochurus Salteri*); List of the Fossils of the Upper Silurian Formation of Gotland, Stockholm, 1885, p. 3 (*Trochurus Salteri*).

[2] Gotl. Silur. Crust. Öfv. K. Vet. Akad. Forhandl., 1885, p. 60.

[3] Q.J.G.S., 1902, vol. lviii, p. 60.

EXPLANATION OF PLATE I.

FIG. 1.—*Lichas* (*Corydocephalus*) *anglicus*, var. *wenlockensis*. Outline restoration of pygidium. × 3.
,, 2.—*L.* (*Corydo.*) *anglicus*, var. *obtusicaudatus*. Outline restoration of pygidium. × 4.
,, 3.—*L.* (*Corydo.*) *hirsutus*. Specimen with eleven thoracic segments. × 2½ (partly restored). Woodw. Mus.
,, 4.—Ditto. Specimen with eleven thoracic segments. × 2½ (partly restored). Brit. Mus.
,, 5.—Ditto. Outline restoration of pygidium from Fletcher's type. × 3.
,, 6.—Ditto. Var. *tuberculatus*. × 3. Woodw. Mus.
,, 7.—*L.* (*Dicranopeltis*) *Woodwardi*. × 1½. Woodw. Mus.
,, 8.—Ditto. Nat. size. Figured by Fletcher as *L. Barrandii* (Q.J.G.S., vol. vi, pl. xxvii, fig. 10). Woodw. Mus.

III.—ON THE ORIGINAL FORM OF SEDIMENTARY DEPOSITS.[1]

By the Rev. J. F. BLAKE, M.A., F.G.S.

THE form of the deposits that are taking place on the sea-bottom at the present day is one of the essential elements required to be known when we wish to interpret the submarine contours, as throwing light on the submergence or elevation of the land in late geological times, or when we propose to use the variation of thickness of the strata deposited during any epoch as an indication of the position of the shore-lines at that time.

In the case of deposits in small or temporary masses of water, their form and arrangement may sometimes be observed directly; but in the case of the deposits in the sea, where we can neither remove the water nor make borings beneath it, we can only avail ourselves of theoretical considerations.

It might have been expected that the original form of various sedimentary deposits would have been considered in detail long ago, but as a matter of fact the few writers who have touched upon the question have mostly been content with the assumption that deposits taken as a whole are thickest near the source of supply, and the figures given in illustration of the arrangement of various kinds, and thereby the shape of each, are remarkable for their variety.[2]

As the theoretical results at which I have arrived differ fundamentally from the ordinary assumptions, it is to be hoped that some one will be able to point out the fallacy, if any, which has led me astray, and to explain more satisfactorily the observed features which appear to confirm the theory. It will be seen, however, that it is just those writers who have paid most attention to the matter who approach most nearly to agreement with my results.

The actual form of any deposit on the sea-bottom, supposed, for the sake of argument, to be flat, will depend first upon the forces to which the material is subject, and secondly upon the nature of the

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[1] A paper read at the Meeting of the British Association, Belfast, September, 1902.

[2] See Godwin-Austen, Q.J.G.S., vol. vi, p. 82, fig. 2 (1850); Hull, Q.J.G.S., vol. xviii, p. 135, fig. 4 (1862); Green, Lectures on Coal, p. 9 (1878), and Geology, p. 211 (1882); Page & Lapworth, Introductory Textbook, p. 59, fig. 22 (1888); Marr, Principles of Stratigraphical Geology, p. 117, fig. 13 (1898); Watts, Geology [illegible]r Beginners, p. 73, fig. 47 (1898).

Geol. Mag. 1903. Decade IV. Vol. X. Pl. I.

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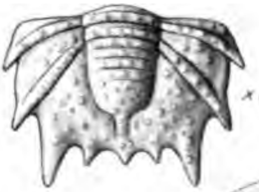

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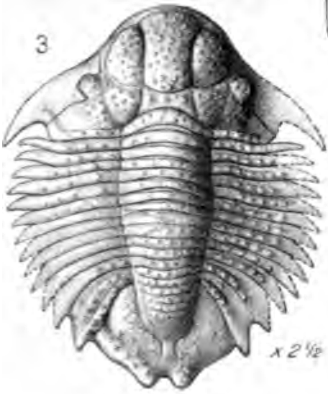

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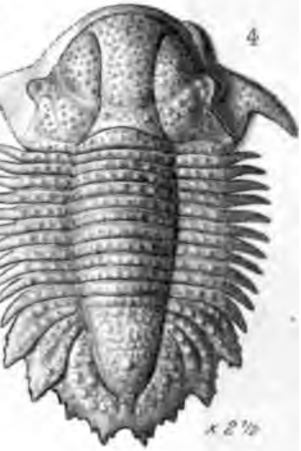

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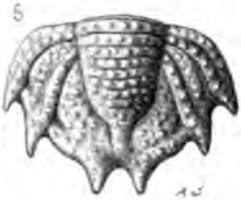

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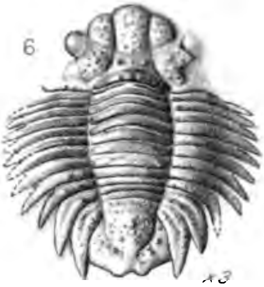

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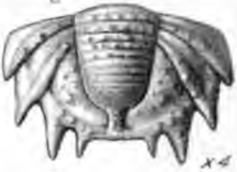

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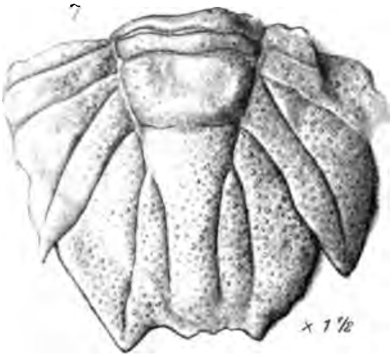

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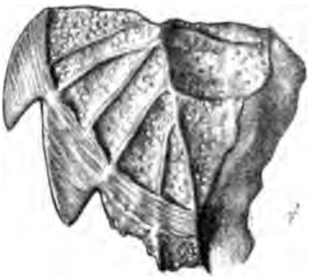

G. M. Woodward del. et lith. West, Newman imp.

Some Wenlock Species of Lichas.

material in relation to those forces. The forces are three, viz., the horizontal currents, the vertical force of gravity, and the resistance of the water to the sinking through it of the material. Of the horizontal currents the most important is that produced by a river running out to sea in a direction perpendicular to the shore. This alone, except the underdrift from breakers, brings *new* materials to form an *original* deposit in the sea. Outward flowing tides, however, act ultimately in a similar manner, and may be considered to belong to the same type, the other type being the currents parallel to the shore, which only shift material already brought. The vertical force of gravity produces a downward velocity which at every instant is combined with the horizontal velocity to make the path of any particle of material a downward sloping one, and the momentary paths combine into a curved one, which becomes vertical when either the particle sinks below the bottom of the current or the current itself is destroyed. The former limit will usually be the first to be reached. The resistance of the water to the sinking of the material depends (1) on the coefficient of viscosity of the water, and (2) on the area, projected on a horizontal plane, of the sinking particle; but for our present purpose we need only note that it is known to be increased by a horizontal movement of the water, and therefore is continually being diminished as the water comes gradually to rest.

In relation to these forces only two kinds of material need be distinguished, namely, that of which the particles are too light, small, or flat to sink in water having the velocity of the given current, and which are carried in suspension so long as that velocity is maintained; and that which consists of stones or grains which are only pushed along the bottom. There may be some small portion of the material on the verge between these two classes, which will pass from the first to the second on a slight decrease of velocity, but as a rule the classes are distinct. The rubbing together of two stones, which is the origin of all detritus, results in the formation of very fine powder and the diminution of the size of the stones; and it is only when the stones are diminished to a floating size that they can form part of the suspended matter. The resulting form of the deposit in these two classes, though similar, will arise from different causes.

In the case of material pushed along the bottom, the result is very simple, and is scarcely a matter of dispute. None of it will be carried further than the spot where the water becomes deeper than the current. When there is no bottom to support the material it will fall to rest at once, and fill up the space between the bottom of the current and the bottom of the sea, as in Fig. 1.

The deposit grows by additions along *a–b*, and not along *a–F*, just in the same manner as a railway embankment grows, by tipping material over the end; it will be truncated at the end according to the angle of rest of the material in sea-water, and if the sea-bottom slopes gradually down it will be thickest at the point of its lower termination, that is, *at the point which is farthest from the source of* *supply.* This original theoretical form will, of course, be much modified in nature by various other causes, but it will not, on the average, be obliterated.

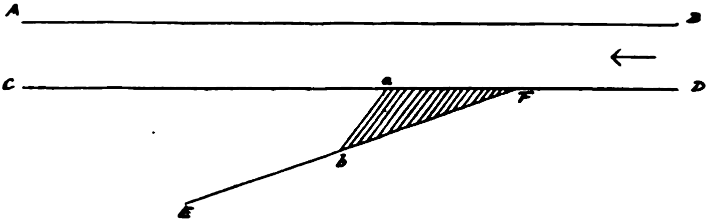

FIG. 1.—SECTION OF DEPOSIT OF LARGE DETRITUS AT A RIVER'S MOUTH.
A–B = sea-level; *C–D*, bottom of the current; *E–F*, shelving bottom of the sea; *a-b–F*, section of the deposit.

Now consider the case of the material in suspension, which is the crux of the whole question. So long as the current is strong enough to push along the heavier particles, it is *a fortiori* strong enough to hold up the lighter in suspension. None, therefore, of the latter (except the diminished stones), will *begin* to sink till after the former has settled, and the whole of the finer deposit will lie seaward of the coarser. At a later time the coarser deposit may grow over the earlier part of the finer, but the two parts that are brought by the same body of water will always be initially separate. As the stream may possibly contain in suspension particles of various rates of sinking, we must consider these separately, and temporarily assume for working out the result that the rate of sinking of the part considered is constant in water of given velocity. The velocity of the stream on reaching the sea will be at last reduced to the stage at which sinking commences, and thereafter it will be continually more and more reduced till it becomes practically zero. We have seen that the result of this diminution of velocity is twofold. It causes the sediment to fall more vertically and against a smaller resistance.

Now the sediment may be considered as arriving in a series of vertical sheets transverse to the stream, and each sheet, as the particles in it sink down, will be spread out horizontally on the bottom. Let us take a section of such a sheet, *a–e*, Fig. 2, and trace the course of the particles in it across a series of equal divisions, in each of which the horizontal velocity is assumed to be constant, so that the paths of the particles in each are all parallel; but in successive ones these velocities are decreased, so that the paths, though still parallel amongst themselves, will be more inclined than in the preceding division. Selecting particles which thus arrive at points equidistant from each other, as b'', c''; d'', so that the line $b''c'' = c''d''$, since $d'd''$ is more inclined than $c'c''$, it follows that $c''d'$ is greater than $b''c'$, and therefore that dc is greater than bc. In other words, if the sediment is uniformly distributed in *ae* a larger proportion of it will be deposited between d'' and c'' than between the preceding equally distant points c'' and b'', or the deposit from a uniform vertical sheet of sediment will continually thicken distally, till the highest particle reaches the bottom, when it will end abruptly. The deposit thus falling from the bottom of the current will be reproduced at any depth where it reaches the solid bottom of the sea below.

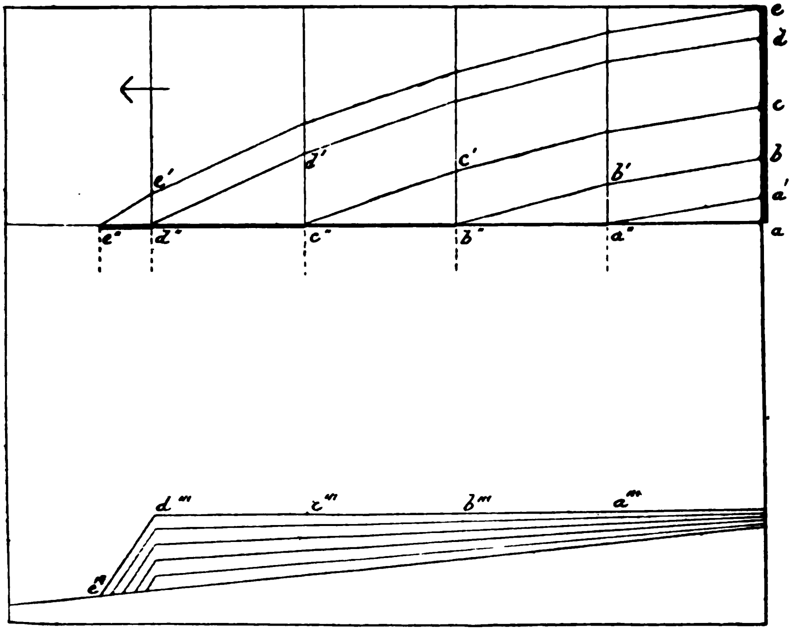

Fig. 2.—The Distribution on the Sea-bottom of a Vertical Sheet of Uniform Sediment.

a–e, the vertical sheet; b–b'–b'' etc., the paths of particles; a'''–e''', the deposit built up by successive sheets.

We must now see whether and how far this result may be modified by other causes. The rising of fresh water over salt will increase the rate of deposition, since the bottom of the current, instead of being horizontal, will curve upwards and so cut more lines of flow. The mixing of sea-water will have the same effect, as the resistance to sinking is known to be less in salt water than in fresh. Evaporation will have little effect, because the detritus will soon leave the surface. But all these causes increase in efficiency with time, and thus will accentuate the thickening of the deposit with increase of distance from the source of supply. On the other hand, the greater velocity of the stream in its centre would diminish the thickening; but this, when the sea is reached, is transformed into a special peculiarity, as will be seen further on.

The most important modification is the following. If a mass of water in motion is retarded in the direction of its flow it must compensate this by spreading out transversely, so that its volume may remain the same. In the present case the current will spread out principally in a lateral direction, so that the sediment *contained in* any given volume of the current falls over a nearly constant area, and the deposit from that volume will be of equal depth throughout. This might seem at first to destroy the foregoing argument, but the thickening therein referred to is produced by the more rapid fall of the sediment in the higher layers *into* this volume, so that the wider lateral spread of the deposit is an *additional* effect. The constant widening of the current will deflect its margin to the right and left, and the flow-lines will form spirals on each side of the main axis, and there deposit some of the detritus they may carry.

And this will have a curious result. The thicker deposits from the slower moving water at the sides of the current will be laid down adjacent to the thinner ones from the faster moving water in the main stream. Thus there will be formed an apparent depression of the sea-bed below the course of the current, though the latter has never touched it. This will be marked by the higher contour-lines bending towards the source of the current. On the other hand, the detritus is carried farther out to sea in a straight direction before deposition, and the lower contour-lines will bend away from the source.

Such, then, is the original form of a single deposit from a current which starts with a given velocity and contains detritus of one rate of sinking. It is thinnest near the source of supply and gradually thickens to a maximum, until it ends seawards with a rapid slope; it expands at the sides with a curved boundary, convex seawards; and it has a depression opposite the source on its proximal, and a prominence on its distal side.

The total result from a current which varies in its velocity and contents will be obtained by superimposing all the wedges thus produced. If the variation be great the shorter wedges, corresponding to the most rapidly sinking detritus, may overbalance the thin ends of the wedges of finer detritus and make the *total* deposit thickest near the shore; but when the physical conditions remain constant for a long period and the current brings uniformly fine detritus, all the maxima will be added together and make the seaward end of the deposit much thicker than the shoreward (see Fig. 2).

The action of tidal and wind currents will modify these results. The motion of such currents may be resolved into two components, perpendicular and parallel to the shore respectively. The former, mostly in connection with the tides, have as detritus carriers a balance outwards, since the sea is essentially a denuding agent on the shore; they may therefore be included in the currents already dealt with. The latter will tend to destroy the details of higher contours, such as the bending shorewards opposite the source of an outward current; also to elongate the original deposits throughout at the expense of their thickness, and so join up the deposits from adjacent outward currents and make the line of greatest thickness a continuous one. Their action, however, is necessarily limited by the depth to which they reach, which, except in the case of ocean currents, is said to be not greater than 100 fathoms. Down to this depth, therefore, the deposits from the suspended material carried by rivers are liable to be supplemented by the contributions made by the waves on the shore, and the contour-line of 100 fathoms will thus be accentuated.[1] This is the 'mud-line' of Dr. Murray, or the most common limit of terrigenous deposits to which the lightest particles—those of organic origin—are carried and form a feeding-ground for fishes, etc.

From this investigation it appears (1) that when a deposit consists of pretty uniform material of fine grain it is likely to end at the part most remote from its source in a steep slope seawards, and that its thickness there is unlimited except by the depth of the sea on which it is formed; (2) that at a greater or less distance from every shore there is likely to be found a narrow zone across which there is sudden fall in the sea-bottom, in which the contour-lines will be crowded together, but from which they may diverge locally opposite the mouth of any muddy river, a higher one towards it and a lower one away from it, and this zone is liable to be specially narrowed and thus accentuated when it occurs at a depth of about 100 fathoms; and (3) that both these results are due to the wedge-shaped form of the original sedimentary deposits in the sea.

Before proceeding to compare these results with nature, some account must be given of the relations of limestones to the deposits already dealt with. Limestone for the most part is introduced into the sea in the form of calcareous salts in solution; it does not usually take a sedimentary form until it has passed through some organism, and will therefore accumulate most where organisms such as precipitate the salts are most abundant. For such organisms to abound it is certainly necessary that there should be (1) abundance of calcareous salts supplied, (2) abundance of oxygen to induce activity, and probably also (3) freedom from mud. For the first condition, nearness to the shore, the source of such salts, is necessary; for the second, nearness to the air, whence the oxygen must be obtained; but for the third, or least certainly necessary one, remoteness from the sources of terrigenous deposits.

Since the discovery of pure Globigerina ooze at abysmal depths, it has been assumed that the third condition outweighs the other two and that limestone is an indication of deep water. Any such assumption is inadmissible, if for no other reason than this, that the Globigerinæ which live on the surface and sink to the bottom when dead are protected from all detrition; they are, therefore, extremely abundant in the ooze; but in the purest chalk the greater bulk is detrital, and must be washed away before the Foraminifera can even be looked for. Globigerina ooze, therefore, throws no light on the relation of limestone to depth. We must start again *ab initio*. There is not at present sufficient information available to enable us to say in what proportions each zone of depth contributes to the production of limestone by the organisms inhabiting it, because we cannot state the average number of the individuals in a given area which make calcareous hard parts, nor the weight of each hard part produced; but we can get some idea of the probable position of the maximum (on the principle that the more individuals there are struggling for existence, the more species will result) by availing ourselves of the results of the *Challenger* Expedition concerning the number of species met with in various zones of depth, as shown in the following table:—

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[1] See N. M. Fenneman, Journ. Geol. Chicago, vol. x, pp. 1–32.

Table showing the number of species of Calciferous Organisms in various zones of depth in the sea.

Range of depth in fathoms.	Calcareous sponges.	Corals.	Crinoids.	Echinoderms.	Lamelli-branchs.	Gasteropods.	Bryozoans.	Brachiopods.	Percentage of the whole.
0–100	29	313	51	79	319	686	224	14	56·3
100–500	8	52	34	53	134	381	124	18	26·4
500–1000	...	26	37	21	21	48	49	2	6·7
1000–1500	...	9	8	18	34	81	7	5	5·3
1500–2000	...	4	9	20	22	20	24	4	3·4
2000–2500	...	3	1	7	5	6	10	3	1·1
2500–	...	1	1	5	12	3	...	1	·7

It is here seen that 82·7 per cent. of the calciferous species occur in the uppermost 500 fathoms, and from the rapid rate of increase probably 80 per cent. in the uppermost 300 fathoms. Add to this that calcareous algæ abound with corals, and also without them, in the highest zone, and that, according to Pourtales, a bank made of Globigerinæ occurs in 100 fathom water off the coast of Florida, and we may feel confident that (possibly with a few exceptions) limestones containing an abundance of any of the above-named organisms cannot have been formed at a depth greater than 300 or 400 fathoms.

Thus the first two conditions for the flourishing of calciferous organisms are found to practically prevail, and the third must be satisfied in some other way than by remoteness from the shore, probably by the absence of mud-bearing streams in their neighbourhood.

Furthermore, it may be noted that the fauna of the deep sea is remarkable for its constancy, but the faunas of shallow water and of limestones are remarkable for their variation from spot to spot. Limestones are also largely detrital, not merely made of comminuted parts, but of impalpable calcareous mud—as in the Lias, the Chalk, and most marbles—and this detrition must have occurred in the zone of detrition, usually limited, as noted above, by the 100 fathom line.

(*To be continued.*)

IV.—THE BLOWN SANDS AND ASSOCIATED DEPOSITS OF TOWAN HEAD, NEAR NEWQUAY, CORNWALL.

By A. SANTER KENNARD and S. HAZZLEDINE WARREN, F.G.S.

[*Note.*—The former author is responsible for the determination of the species and information relating to them; the latter author, for the field notes and other parts of the paper.]

INTRODUCTION.

AT Towan Head and in the cliffs of Fistral Bay, near Newquay, there is seen, at a few feet above high-water mark, the remains of the Pleistocene Raised Beach. This consists of pebbly beds associated with ancient blown sands, sometimes of considerable thickness. Above this series of deposits comes the Head or Rubble Drift, formed during a greater elevation of the land.[1] These beds have been fully described by many authors—De la Beche,[2] W. A. E. Ussher,[3] Sir Joseph Prestwich,[4] and others. While capping the Head and Raised Beach, and on the top of the cliff, there is a series of more recent Æolian sandy beds.

Inland from Fistral Bay the dunes of recent blown sand cover a considerable area, but these are not discussed in the present paper. Attention is here directed to the superficial deposits of Towan Head. The dunes which cover the surface at Fistral Bay are quite recent accumulations, and are, in fact, still in process of formation, as the westerly winds from the Atlantic blow up the sand left dry upon the present beach. The recent dunes extend to Towan Head; but there are other sands, beneath them in stratigraphical position, yet still capping the Head, which are of greater antiquity, and present certain points of interest.

Mr. W. A. E. Ussher[5] gives the following section of the cliff toward the north end of Fistral Bay, near Towan Head:—

	feet.
Recent blown sand	3
Sandy soil with angular fragments of slate	2
[Head] Buff loam with angular stones and boulders	2
[Pleistocene blown sand of the Raised Beach] Buff sand	1
[Raised Beach] Coarse and fine gravel of quartz, dark grey grit, slate, and occasionally flint	4

The 'sandy soil' immediately above the Head is a representative of the beds chiefly dealt with here.

On the east side of the promontory of Towan Head, and close to the lifeboat house, there is a quarry in the cliff which exposes a section of these beds. At this spot the deposit consists of sand about four feet in thickness, containing many land shells, together

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[1] R. A. C. Godwin-Austen: Quart. Journ. Geol. Soc., 1850, vol. vi, p. 94; 1851, vol vii, pp. 121–126.

[2] H. T. de la Beche: "Report on the Geology of Cornwall," etc., 1839, p. 426, etc.

[3] W. A. E. Ussher, "The Post-Tertiary Geology of Cornwall": GEOL. MAG., 1879, Dec. II, Vol. VI, pp. 206–207.

[4] J. Prestwich: Quart. Journ. Geol. Soc., 1892, vol. xlviii, pp. 281–282.

[5] GEOL. MAG., 1879, p. 206.

material in relation to those forces. The forces are three, viz., the horizontal currents, the vertical force of gravity, and the resistance of the water to the sinking through it of the material. Of the horizontal currents the most important is that produced by a river running out to sea in a direction perpendicular to the shore. This alone, except the underdrift from breakers, brings *new* materials to form an *original* deposit in the sea. Outward flowing tides, however, act ultimately in a similar manner, and may be considered to belong to the same type, the other type being the currents parallel to the shore, which only shift material already brought. The vertical force of gravity produces a downward velocity which at every instant is combined with the horizontal velocity to make the path of any particle of material a downward sloping one, and the momentary paths combine into a curved one, which becomes vertical when either the particle sinks below the bottom of the current or the current itself is destroyed. The former limit will usually be the first to be reached. The resistance of the water to the sinking of the material depends (1) on the coefficient of viscosity of the water, and (2) on the area, projected on a horizontal plane, of the sinking particle; but for our present purpose we need only note that it is known to be increased by a horizontal movement of the water, and therefore is continually being diminished as the water comes gradually to rest.

In relation to these forces only two kinds of material need be distinguished, namely, that of which the particles are too light, small, or flat to sink in water having the velocity of the given current, and which are carried in suspension so long as that velocity is maintained; and that which consists of stones or grains which are only pushed along the bottom. There may be some small portion of the material on the verge between these two classes, which will pass from the first to the second on a slight decrease of velocity, but as a rule the classes are distinct. The rubbing together of two stones, which is the origin of all detritus, results in the formation of very fine powder and the diminution of the size of the stones; and it is only when the stones are diminished to a floating size that they can form part of the suspended matter. The resulting form of the deposit in these two classes, though similar, will arise from different causes.

In the case of material pushed along the bottom, the result is very simple, and is scarcely a matter of dispute. None of it will be carried further than the spot where the water becomes deeper than the current. When there is no bottom to support the material it will fall to rest at once, and fill up the space between the bottom of the current and the bottom of the sea, as in Fig. 1.

The deposit grows by additions along *a–b*, and not along *a–F*, just in the same manner as a railway embankment grows, by tipping material over the end; it will be truncated at the end according to the angle of rest of the material in sea-water, and if the sea-bottom slopes gradually down it will be thickest at the point of its lower termination, that is, *at the point which is farthest from the source of* next group, is a comprehensive one, and does not necessarily imply a forest growth. The woodland forms all require shade, moisture, and a growth of herbage; they could not exist on the sand dunes at present. The sand dune group includes those species which live there at the present day, and whose natural habitat it is; whilst the intermediate group comprises those species which can accommodate themselves to the sand dunes, though their true habitat is the same as that of the woodland group.

On examining the table it will be noted that in the lowest beds, viz. the top of the Head, the woodland fauna is alone represented, the true sand dune forms being absent. As we gradually go higher the woodland forms die out, and they are replaced by the sand dune group. It may therefore be inferred that the change in the conditions was not a sudden one, but gradual, and one operating over some considerable time.

A similar phenomenon is seen at Harlyn Bay, where in the Neolithic layer a woodland fauna is represented, which was subsequently driven out by the blown sands.

It is therefore evident that, at the time this woodland fauna lived on the north coast of Cornwall, the sea must have been at some considerable distance from the present shore.

DETAILS OF THE SECTIONS.

Taking now the sections seen on the cliffs on the west side of Towan Head, and beginning at a point a little north of the lifeboat house and working southward, the first point noticed was on the northern side of a cutting that leads to the beach. Here there is seen a very rubbly surface soil, beneath which there is about 2 feet to 2 ft. 6 in. of rubbly sand, underlaid with Head; while below, among the rocks of the shore, may be seen remains of the consolidated blown sands of the Raised Beach Series. In the rubbly sand, and at a depth of about eighteen inches from the surface, a fragment of pottery was found *in situ*. It is of the coarse, handmade type that is especially characteristic of the Neolithic period, though whether it may belong to that period or not one cannot state with certainty. For, though characteristic of Neolithic times, this kind of pottery continued in use to a later date when better kinds were also made. At this spot, and at the same depth as the pottery, a few shells were collected. The list is placed in column A of the table of fauna. In the same bed, but a short distance further to the south, those given in column B were found. In the bottom of the sand, just above the Head, and immediately below where the pottery was found, there were those given in column C.

In the top of the Head, a few yards further to the south (on the other side of the cutting that leads to the beach), shells were very abundant; those that were collected are shown in column D. These were the lowest in stratigraphical position of any shells that were found. Many of them were firmly attached to the angular fragments of rock which form so large a part of the Head.

On the top of the Head, and beneath three or four feet of blown sand, at some little distance to the south of the lifeboat house, a flint was found that shows some signs of having been chipped. It may be quite accidental, and is certainly too indefinite to rank as evidence, but since flint is scarce and kitchen-middens occur at no great distance and on nearly the same horizon, and there is also the pottery already mentioned, it seems worth while to mention it.

Still further to the south, at the extremity of a miniature point to the north-north-west of the Headland Hotel, the cliff is capped by about six feet of loamy sand, with the usual layers of *Mytili*; while at the bottom of the sand, and separated from the Devonian slates by a very thin deposit of Head, there are two kitchen-middens. These are only a few inches in thickness, and they are separated from each other by a layer of loamy sand. They are largely made up of shells of *Mytili*, though *Patellæ* are also common, together with charred wood and stones showing the action of fire; there is also a great amount of black material in their composition. A number of shells were collected from the sands above the kitchen-midden; the list is given in column E. Only a few land shells were seen in the kitchen-midden; the list is in column F.

At the next small point in the cliffs, on the opposite side of a miniature cove, the following section was measured:—

	feet.
Holocene blown sand, with a layer of *Mytili* at about five feet from the surface	9
Head: angular rock débris and loam	5
Pleistocene blown sand, partially consolidated, belonging to the Raised Beach Series	8

The Pleistocene blown sand and Head are rudely interstratified together at their junction. At the point where the section was taken, the rocks of the shore are high, and the old Blown Sand of the Raised Beach is eight feet in thickness; but in the little coves where the rocks are lower, the Raised Beach Series descends correspondingly to within a few feet of high-water mark, and thus indicates a greater thickness. At the lower points there are frequently beds of pebbles at its base, though these are not so strongly developed as in Fistral Bay.[1] In the upper part of the sand, above the layer of *Mytili*, and at from two to three feet from the surface, the species shown in column G were collected. At from five to six feet from the surface, and in and below the layer of *Mytili*, were those given in column H.

Following the cliffs further to the south, and just west of the Headland Hotel, it is to be noted that the layer of *Mytili* gradually rises up to the surface, while the sands between that layer and the Head thicken proportionally. This, though much flattened by time, is evidently an ancient dune. At a little distance in this direction, and near the next small cove, another kitchen-midden is seen in the sand at about five feet from the surface. This is in every way similar to those already described, but, so far as can be seen, it is of smaller extent. At this spot there is a particularly clear section of the Holocene blown sands and upper part of the Head. The latter is seen to gradually lose its distinctive character towards the top, and to pass almost insensibly into the blown sand above. Along the line of junction, through a thickness of about nine inches, land shells were fairly abundant; those collected are given in column I.

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[1] They were probably situated further out to sea than the pebble beds of the bay, and so have been destroyed.

The bed in which these (column I) occurred was a loamy sand, intermediate alike in position and character between the Head and the blown sand above. They are consequently on a somewhat higher horizon than those in column D. It is worthy of note that the proportion of pure woodland forms is also less, while those that can accommodate themselves to sand dunes also are more abundant.

A few feet above this bed, in the lower part of the sand, and on about the same level as the kitchen-midden, a few shells were collected; they are shown in column J.

To the east of the Headland Hotel there are well characterized dunes of recent blown sand. These are almost the last stragglers in this direction of the great dunes of Fistral Bay. A small section in one of these showed one of the familiar layers of *Mytili*; a few of these were collected, together with some of the characteristic sand-dune forms; they are given in column K.

In the last column of the Table of Fauna is a list of species from various situations at Towan Head. The pure woodland and chiefly woodland forms were mostly taken along the line of junction between the Head and the Holocene blown sand, but in places where the sections were not quite clear. This list includes two species not recorded elsewhere in the Table.

With more prolonged work upon these beds the list of species could undoubtedly be extended, but the conclusions based upon the nature of the dominant species would not thereby be affected.

AGE AND MODE OF FORMATION OF THE DEPOSITS.

With regard to the precise age of the sands immediately above the Head there is no definite evidence. So much as is available has already been mentioned—the pottery (column A of the Table), which is very probably Neolithic, the flint, which may possibly be of the same age, and the kitchen-middens. Neither is there any evidence at present as to the age of the kitchen-middens, and opportunities for a thorough investigation were wanting. Kitchen-middens have previously been found in the neighbourhood of Newquay, and there are the important discoveries at Constantine and at Harlyn Bay,[1] which are sufficient to stimulate further search on the archæological side.

In reference to the mode of formation of these deposits, one notices that in the passage from Pleistocene blown sand to Head, and again from Head to Holocene blown sand, there is, as it were, a struggle to hold the field between the accumulation of sea sand driven up by the wind and the accumulation of rock débris and loam under atmospheric erosion. In the cliff sections to the westward of the Headland Hotel the Pleistocene blown sand and the Head are rudely interstratified together at their junction, while at a short distance away the Head is seen to pass almost insensibly upward through loamy sand into the Holocene blown sand above. The former case is evidently due to the fluctuation in the dominance of the one mode of accumulation or the other, during a gradual change in conditions, as already suggested. There can be little doubt but that this was caused by a gradual elevation of the land, and consequent removal from the source of supply of the sand, together with increase in erosion of the surface; and when, after the Head, the Holocene blown sands became dominant, to an almost equivalent depression.

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[1] C. Spence Bate: Trans. Devon Assoc., 1864, vol. i, pp. 138–139; Report Brit. Assoc., 1864, p. 88. The Rev. R. Ashington Bullen: "Harlyn Bay and the Discoveries of its Prehistoric Remains"; London, 1902.

One naturally speaks of these changes in the relative level of land and sea in terms which refer to the elevation and depression of the land. Recent researches have shown, however, that the surface of the sea is by no means the uniform level that we have been wont to imagine; and that these changes may equally well be due to local fluctuations in its level. But for purposes such as that of the present paper, one can be content to leave the question unsolved.

V.—NOTES ON FOSSIL AND RECENT SHELLS OBTAINED ON A VISIT TO CORNWALL.

By J. P. JOHNSON.

THE following notes were made during the little time I was able to devote to leisure while staying at Camborne in order to study the methods there employed of mining and dressing the tin-bearing rock. They therefore deal only with places within easy reach of that town.

The whole of this district is made up of extremely ancient rocks, of which I must content myself with saying that they afford a boundless field for those interested in the variation and alteration of granite, in the killas through which it rises, and in the granite-porphyry and other dykes with which these are traversed; or for those seeking to unravel the many problems connected with the mode of occurrence of the tin and copper lodes. Here and there, resting on these old rocks, are scattered patches of comparatively recent deposits, none of which date back to before the Neogene era.

The most interesting of these is certainly the fossiliferous Pliocene clay at St. Erth. All information concerning it was summarized by Clement Reid[1] in 1890, and increased in 1898 by Alfred Bell,[2] who also figured some of the more noteworthy shells. The deposit is of very limited extent, and is situated in the valley, then probably a strait, which connects Mounts Bay and St. Ives Bay. The exposures, which I was enabled to examine through the courtesy of the Rev. C. R. D. Carter, are all very small, the deepest being as follows:—

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[1] "Pliocene Deposits of Britain": Mem. Geol. Surv., London, 1890.

[2] "On the Pliocene Shell-beds at St. Erth": Trans. Roy. Geol. Soc. Cornwall, 1898, vol. xii.

	feet.
Coarse sand	7
Brown and mottled clay, passing into blue ...	3

The shells occur in the lower (blue) portion of the clay, and, as a rule, are not by any means common, though here and there, in sandy patches, those of *Bittium reticulatum* occur in great quantity. Next in order of abundance are those of *Nassa semireticosa*, two or three being met with in every cubic foot of clay. The following list shows the number I obtained of each species and the result of two days' digging. Those indicated by an asterisk are figured by Alfred Bell in the paper already cited; the others are figured by S. V. Wood in the volumes of the Palæontographical Society. The specific names used by these two authors are here employed, but prior ones are given in parentheses. Those species of which I only obtained fragments are indicated by the letter F.

I would here remark that I am much indebted to Mr. R. B. Newton for his kindness in enabling me to compare the specimens in the Geological Department of the British Museum (Natural History).

1. *Columbella erythrostoma.*
7. *Ringicula ovata.**
30. *Nassa semireticosa** (? = *serrata*, Br.).
2. *Nassa recticosta.**
1. ,, *granifera.*
2. ,, *mutabilis.**
6. *Turritella incrassata* (=*triplicata*, Br.).
1. *Pyramidella læviuscula.*
1. *Odostomia conoidea.*
300. *Bittium reticulatum.*
1. *Natica proxima* (=*sordida*, Phil.).
1. ,, *catena.*
2. *Calyptræa chinensis.*
1. *Paludestrina subumbilicata* = *ventrosa*, Mont.
4. *Rissoa ovalis.**
2. ,, *Montagui.**
1. ,, n.sp. ?
1. ,, sp. ?
1. *Calliostoma*, sp. ?
1. *Montacuta bidentata.*
2. *Lucina borealis.*
F. *Pecten*, sp. ?
F. *Ostrea*, sp. ?
F. *Nucula*, sp. ?

I also found one or two Foraminifera.

South of Godrevy lighthouse, resting on a terrace of killas, is a Pleistocene beach. It is made up of pebbles of killas, granite, and quartz, and is overlain by a variable thickness of rubble-drift consisting of similar materials embedded in loam. I did not succeed in finding any organic remains in either of them, but my friend Mr. F. A. Ginever has procured a couple of shells of *Patella vulgata* from the ancient beach.

On the top of the cliffs, but lying back some distance from the edge, are extensive Holocene sand-hills or 'towans.' These have long ceased to move, being sealed up under a layer of turf. They contain numerous shells of *Helicella itala*, *H. virgata*, and *H. barbara*, whilst I also found one of *H. caperata*.

On the further side of the sand-covered gap, where the red stream empties itself into the sea, are Gwithian Towans. From a section in one of them, at a depth of ten feet, I obtained an assemblage of molluscan remains similar to that recorded above, as well as a few shells of *Helix aspersa* and one each of *Cochlicopa lubrica* and *Vallonia pulchella*.

During a brief visit to Hayle I came across an interesting deposit overlooking the mouth of the river from the right bank. It is exposed at the top of a quarry (marked "gravel pit" on the old six inch map), and is as follows:—

		feet.
(*a*)	Clean sand with land shells	2
(*b*)	Dirty compact sand with *Helicella virgata* and occasional broken mussel and cockle shells	1½
(*c*)	Clean sand with *Helicella barbara* and cockle-shells	1
(*d*)	Layer of broken mussel-shells.	
(*e*)	Pieces of killas in clay (rubble-drift), the top half foot sandy with fragments of mussel-shells	5
(*f*)	Killas.	

The most interesting feature is, of course, the layer of broken mussel-shells, which is clearly the remains of an old kitchen-midden. From it I obtained a neat little flint flake of the arrow-head type, the tip of which had been broken off. From bed (*b*), which also bears evidence of the presence of man, I obtained a shell of *Helix aspersa* and a tooth which my friend Hinton has identified as belonging to sheep.

While speaking of flint flakes I may mention that I picked one up near Godrevy and another on Carn Brea. At the latter place there are a number of hut-circles, from the interior of which numerous arrow-heads, scrapers, and other implements have been exhumed.

From the adjoining Riviere Towans I obtained shells of the following molluscs:—

Vitrea nitidula (Drap.).
Pyramidula rotundata (Müll.).
Hygromia granulata (Ald.).
Helicella itala (L.).
,, *caperata* (Mont.).
,, *virgata* (Da C.).
,, *barbara* (L.).
Helix aspersa, Müll.
,, *nemoralis*, L.
Cochlicopa lubrica, Müll.
Clausilia bidentata, Ström.
Carychium minimum, Müll.
Patella vulgata, L.

With the exception of *Carychium minimum*, *Cochlicopa lubrica*, *Clausilia bidentata*, and *Hygromia granulata*, they were all common. One of the shells of *Helicella barbara* is nearly 19 mm. in length.

I made one or two expeditions in search of living non-marine molluscs, and the following list of the species I obtained may be of service to compare with that of the fossil ones:—

Testacella maugei, Fér.
Limax maximus, L.
Agriolimax agrestis (L.).
Amalia Sowerbyi (Fér.).
Vitrina pellucida (Müll.).
Vitrea cellaria (Müll.).
,, *lucida* (Drap.).
,, *nitidula* (Drap.).
,, *excavata* (Bean).
Euconulus fulva (Müll.).
Arion ater (L.).
Pyramidula rotundata (Müll.).
Helicella itala (L.).
,, *caperata* (Mont.).
,, *virgata* (Da C.).
Helicella barbara (L.).
Hygromia granulata (Ald.).
,, *hispida* (L.).
,, *revelata* (Fér.).
,, *rufescens* (Penn.).
Acanthinula aculeata (Müll.).
Vallonia pulchella (Müll.).
Helix aspersa, Müll.
,, *nemoralis*, L.
Cochlicopa lubrica (Müll.).
Pupa cylindracea (Da C.).
Clausilia bidentata (Ström.).
Carychium minimum, Müll.
Ancylus fluviatilis, Müll.

The most interesting of these is certainly the rare *Hygromia revelata* (Fér.), which I came across at St. Michael's Mount. I found it high up on small ledges of rock.

From the same locality I obtained the two shells of *Testacella maugei*. One of them is unusually large, measuring 18 mm. from the tip of the vestigial spire to the anterior margin. This discovery considerably extends the known range of this species in Britain.

I obtained only one specimen of *Vitrea lucida*. In the woods among the dead leaves I found *Vitrea excavata* in abundance, also, among the ivy, the pretty little *Acanthinula aculeata*, and, in hollows, *Vitrea fulva*. In the hedgerows, and particularly among nettles, I obtained *Hygromia granulata*, *H. hispida*, and *H. rufescens*; and on walls, *Clausilia bidentata* and *Pupa cylindracea*. On the sand-hills along the coast *Helicella barbara* occurred in myriads, together with *H. virgata*, *H. itala*, and *H. caperata*; it is noteworthy on account of the abnormal shape of the shell and its limited distribution in this country.

Ancylus fluviatilis is the only aquatic mollusc I succeeded in finding. It was common on the stone-strewn bed of the streams.

VI.—On two Trilobites from the Devonian Slates of Cornwall, obtained by Walter Barratt, Esq.

By Henry Woodward, LL.D., F.R.S., F.G.S.

HAVING been favoured by Mr. Walter Barratt, of Sunnybank, Newquay, Cornwall, with the opportunity of examining two Trilobites from the Devonian slate-rock—(1) from a cove near Trevose Head, (2) from the shore of the mainland opposite Trescore Island, Porthcothan, Cornwall,—I gladly avail myself of his permission to publish a note thereon.

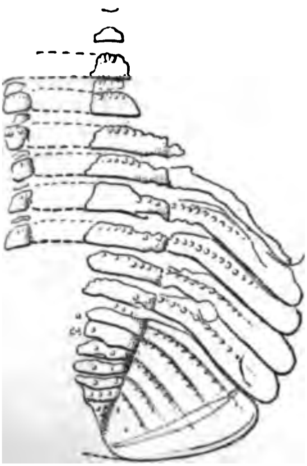

Fig. 1.—A new Devonian Trilobite from Cornwall: *Homalonotus Barratti*, sp. nov. [illegible] nat. size. Devonian Slates: Trevose, Porthcothan, Cornwall.

Mr. Howard Fox, F.G.S., of Falmouth, has lately directed attention to some recent discoveries of obscure organisms from the same Devonian rocks at a meeting of the Royal Geological Society of Cornwall (November, 1899), and published afterwards in the GEOLOGICAL MAGAZINE (April, 1900, Dec. IV, Vol. VII, pp. 145–152, Pl. VII); he describes and figures some of the most noteworthy of these, giving also a list of localities where found.

Mr. Fox mentions the rocks both north and south of the River Camel, in Padstow Harbour, where simple cup-corals and fragmentary crinoidal remains have been obtained; he also records that at Trevone fossils occur at several distinct horizons — *Pteraspis, Orthoceras, Bactrites, Goniatites, Euomphalus, Cardiola, Centronella, Phacops, Tentaculites, Styliola, Amplexus, Favosites*, and *Pachypora*. At West Newtrain Bay *Scaphiocrinus* and a Favosite coral were obtained. At Mother Ivey's Bay, *Tentaculites, Centronella, Hyolithes*, and crinoidal stems. Porthcothan Cove, south of Trevose Head, has yielded *Petraia, Pleurodictyum, Phacops*, sp., and obscurely shown examples of *Orthoceras* and *Goniatites*. Lower Butter Cove yields similar fossils to Porthcothan and Porth Mear. Bedruthan Steps—here *Steganodictyum* (= *Pteraspis*), *Orthoceras, Sphærocrinus*; some corals, *Pleurodictyum, Aulopora*?, *Petraia* occur, with *Pteroconus mirus*, etc. At Watergate or Tregurrian Bay and Beach, 2¼ miles north of St. Columb, Porth; also between Fowey and Polperro, the slates are found to be highly fossiliferous.

HOMALONOTUS, König, 1825.

Homalonotus is a very characteristic form of Trilobite, and is easily distinguished from other genera, even from its nearest ally, *Calymene*.

The peculiar trilobation of the body-rings, so conspicuous in most genera, is very indistinct in *Homalonotus*, especially in the thoracic segments, although in some species it is better marked in the pygidium. The shape of the body is elongate, convex, with steep sides, and a very broad axis, scarcely distinguished from the pleuræ. There are thirteen body-rings, deeply grooved, and the fulcrum is close to the axis in most of the species. The head is triangular, with an obscure quadrate glabella slightly lobed, and a quadrate labrum; the surface of the body is scabrous, occasionally spinous. The pygidium is generally narrow and pointed, except in a few species which have a more rounded contour.

Of the twenty species recorded, by far the larger number are from the Silurian. The following are from the Devonian of Devon and Cornwall (and two are also exotic, namely, *H. Herscheli* and *H. Pradoanus*):—

Homalonotus	*armatus*, Burm.	Devonian:	Cornwall.
,,	*Champernownei*, H. Woodw.	,,	Torquay.
,,	*elongatus*, Salter.	,,	S. Devon.
,,	*goniopygæus*, H. Woodw.	,,	Torquay.
,,	*Herscheli*, Murch.	,,	Devon and S. Africa.
,,	*Pradoanus*, De Vern.	,,	Spain.
,,	*Barratti*, H. Woodw.	,,	Cornwall.

The Devonian species of *Homalonotus* occur in Cornwall and Devon, and extend into Germany and Spain. One species is met with as far off as South Africa (*H. Herscheli*).

All the Devonian Trilobites appear to be referable to Mr. Salter's section of Homalonoti *with spines*, which he named ***Burmeisteria***: this division includes all those species having the body elongate, convex; head triangular; eyes approximate on gibbous cheeks; glabella distinct, lobeless, sinuous; thorax slightly lobed and spinous, as is also the many-ribbed, pointed tail. He takes for his type *H. Herscheli*, from the Devonian.

Mr. Salter's *Homalonotus elongatus* is founded upon a *tail only*, remarkable, even in this elongated genus, for its length and shape. This form is very strongly trilobed, and appears to have had four pairs of spines along its median axis and two pairs upon the lateral portion. (See Salter: Mon. Pal. Soc., 1865, pt. ii, p. 122, pl. x, figs. 1, 2.)

Homalonotus Champernownei has little or no signs of trilobation, and is rather larger than the celebrated *H. delphinocephalus* from the Wenlock Limestone of Dudley; it has thirteen free moveable thoracic segments with broadly expanded pleuræ, each rib armed with a pair of spines placed about one inch apart; the head also had three pairs of spines placed on the lateral portion, and three along the medial line; there is no evidence of cheek-spines; the pygidium is imperfect. (See GEOL. MAG., 1881, Dec. II, Vol. VIII, p. 489, Pl. XIII.)

In Mr. Barratt's specimen from a cove in the Devonian slates of Trevose Head, Cornwall, we have only evidence of one side of the pygidium, five of the posterior free thoracic segments, and fragments of others. Assuming these to have been compressed longitudinally so as to make them appear disproportionately broad and short, they still have the characteristic deep falcate margins to the free segments and the six or seven well-marked coalesced segments to the pygidium seen in other species of this genus; but, though only a fragment, we notice that each segment, both in the free thoracic rings and in the coalesced segments of the tail, is marked by a single row of small rounded tubercles uniform in size, ten on each pleura and an uncertain number on the axis of the body; those on the coalesced segments of the tail diminishing in number backwards from ten to eight, to six, to four, to three. The ribs of the tail do not extend to the margin, but leave a smooth rounded border. It would be impossible to give a more detailed description of so mere a fragment, but the single row of extremely regular tubercles on each segment suffices to separate it from other Devonian or Silurian forms with which I am acquainted. The Figure, which is reduced to two-thirds natural size, serves to convey a correct idea of this interesting fragment.

So soon as attention is directed to the occurrence of Trilobites in these Devonian slates at Trevose, no doubt many more specimens will be found to reward the diligent seeker after organic remains. Dr. Arthur Smith Woodward, F.R.S., in his Catalogue of Fossil

Fishes, vol. ii, writes:—"Fragments of Pteraspidian shields, not sufficiently complete for precise determination, are met with in the Lower Devonian of Cornwall, and were originally described as fossil sponges by McCoy."[1]

Their fish-like character was first noted by Mr. C. W. Peach (Report Brit. Assoc., 1843 (1844), Trans. Sect., p. 56), who collected many specimens; they were subsequently assigned to *Pteraspis* by J. W. Salter (see Wyatt-Edgell, Geol. Mag., Vol. V (1868), p. 247), and finally named *Scaphaspis Cornubicus* by E. Ray Lankester & H. Woodward (Geol. Mag., Vol. V (1868), p. 248) and J. E. Lee, ibid. [2], Vol. IX (1882), p. 105, Pl. III, Figs. 2 and 3. Numerous fragments from Polperro are preserved in the Lee Collection in the British Museum, and larger specimens from Fowey.

These obscure fossils, first described as sponges by McCoy, were also referred to cuttle-fishes by Roemer (1855), under the name of *Archæoteuthis Dunensis* (*Palæontographica*, Dunker & von Meyer, vol. iv, p. 72, tab. xiii), now referred to *Scaphaspis Cornubicus*. The late Dr. S. P. Woodward (1856) called attention to the true ichthyic character of Roemer's supposed *Archæoteuthis* in his "Manual of the Mollusca" (p. 417).

Phacops, Emmrich, 1845.

Phacops latifrons (?), Bronn.

The specimen which I refer to this species is *only a fragment* of a small example from the mainland shore opposite Trescore Island, Porthcothan, Cornwall.

It is seen in profile; the head is *very obscure*, and is followed by *about* ten thoracic rings with rounded bevelled pleuræ; the line of the median axis is indicated on the one side preserved; the other side is wanting. Length of thoracic segments 15 mm., depth of same as half seen 15 mm.; length of pygidium 6 mm., depth of profile seen 9 mm.; there is a distinct raised and grooved border to the pygidium, but the furrows of the coalesced segments forming the tail-plate are worn away (by the sea?).

I have referred this example to *Ph. latifrons* ?, doubtfully (as the specimen is so imperfect), because it is a very common Devonian Trilobite and has been obtained at quite a number of localities in Devon and Cornwall. It is to be hoped that better specimens may shortly be met with by Mr. Barratt or other Cornish geologists.

Horizon.—Lower Devonian. Localities: Hope and Barton, South Devon; near Liskeard and Totnes, in slates with *Pleurodictyum problematicum.*

Upper Devonian.—Barnstaple, Croyde, Brushford, Pilton, etc., abundant. Foreign localities: Rhenish Prussia, Belgium, France, Russia; Andes, South America.

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[1] F. McCoy: Ann. and Mag. Nat. Hist. [2], vol. viii (1851), p. 481, and Brit. Palæozoic Foss. (1851), pl. ii A, figs. 1–3.

VII.—BELEMNITES OF THE FARINGDON 'SPONGE-GRAVELS.'

By G. W. LAMPLUGH, F.G.S.

DURING a preliminary traverse of the Lower Cretaceous outcrop in the Midlands last June, I visited Faringdon for the first time, and examined the famous sections in the 'Sponge-gravels.' My chief aim was to obtain some evidence by which the relative position of these beds in the Lower Cretaceous series might be determined. The greater part of the fauna was so anomalous and peculiar that it afforded little or no assistance towards this purpose, and the only common fossil which gave definite promise of service was the fragmentary *Belemnites*, which I found in unexpected abundance. It is true that I had previously noticed a few specimens among the Faringdon fossils in the Natural History Museum (from the Caleb Evans' Collection) and in other public collections, and had seen references to *Belemnites* in descriptions of the 'Sponge-gravels'; but I went with the impression that its occurrence was rare and exceptional, whereas I found that it could be collected plentifully from every pit, though always in a more or less worn and fragmentary condition, and generally encrusted with small oysters, serpulæ and polyzoa, and perforated by marine borers. The scant attention which the fossil has hitherto received is probably due to the prevalent opinion that it is derivative from the Jurassics, but this opinion is almost certainly erroneous, as I shall now try to show.

In the large number of specimens which I obtained only one species appears to be represented, and this species cannot, I think, be matched among Jurassic Belemnites. A careful comparison of the form with my large collection of Lower Cretaceous Belemnites from Speeton and Lincolnshire has satisfied me that all the specimens collected or seen by me may be referred to the species figured and described by Professor Pavlow ("Argiles de Speeton," pl. vii, figs. 13 and 14, and p. 88) as *Belemnites Speetonensis*. This species occurs abundantly in the 'zone of *Bel. Brunsvicensis*' at Speeton and in Lincolnshire, and is indeed probably an offshoot or extreme variety of the zonal species. In fragments of the thicker portion of the guard the Faringdon specimens might be mistaken for *Bel. lateralis*, which occupies a well-marked zone at or below the base of the Lower Cretaceous in the north-east of England; but when the pointed end is preserved, the tapering outline, depth and slight grooving strongly distinguish the species. The Speeton fossils are in a different state of preservation; but specimens of *Bel. Speetonensis* in my collection from the Tealby Limestone of Lincolnshire so closely resemble the best examples from Faringdon that if mixed without identifying marks they would be very difficult to separate.

I noticed a difference in the average size of specimens from different pits at Faringdon which I thought at first might be of import; but a simple explanation of this distribution soon presented itself. The Faringdon 'gravels' have clearly been heaped together as a current-swept bank on the old sea-floor; and materials of different size and density have been rudely assorted by the currents, the heavier preponderating in one place, the lighter in another; and where the pebbles are largest, there also are the largest Belemnites found.

From the character of the deposit it has long been recognized that only a small proportion of its organisms can have actually lived where they occur. The case of the Belemnites is not therefore different from that of the majority of the fossils, except that, owing to their weight, brittleness and shape, they have suffered greater attrition than the shells during transport. The presence of numerous pebbles derived from older rocks, as large and larger than the Belemnites, does indeed show that there is no inherent impossibility in the view that these also might be derivative; but the determination of the fossils as representing only a single species, and moreover, one which is not of Jurassic age, is strong evidence against this view. It cannot, indeed, be proved that the specimens are *exactly* of the age of the deposit, but I think it is certain that they cannot be *much* older; and that at any rate they were lying on the sea-floor along with other organisms which were swept together to form the bank.

We will now consider what indication these Belemnites give as to the age of the 'Sponge-gravels.' *Bel. Speetonensis* at Speeton and in Lincolnshire occurs only in the 'zone of *Bel. Brunsvicensis*,' and therefore in beds comparatively high in the Lower Cretaceous Series. The uppermost portion of this zone contains *Amm.* (*Hoplites*) *Deshayesi* and other characteristic fossils of the Atherfield Clay and lowest part of the Lower Greensand of Kent and the Isle of Wight; and although the zonal Belemnite has not yet been observed to occur in these beds in the south of England, the correlation of the Atherfield Clay with the upper part of the 'zone of *Bel. Brunsvicensis*' of Speeton appears to be well established. Whether the Faringdon Belemnites are actually contemporaneous with or somewhat older than their matrix, the 'Sponge-gravels' cannot represent a lower horizon than the upper part of the 'zone of *Bel. Brunsvicensis*.'

In the Hythe Beds of Kent and at a corresponding horizon in the Isle of Wight there is occasionally found a form of *Belemnites* which is the same as a species occurring at Speeton,[1] above the 'zone of *Bel. Brunsvicensis*' and below the 'marls with *Bel. minimus*.' The nomenclature of this species has been greatly confused, and stands in need of careful elucidation; in some lists it appears as *Bel. jaculum* and as *Belemnitella plena*, from both of which, however, it is quite distinct; it is probably the form known on the Continent as *Bel. fusiformis*, Voltz. I did not find any trace of this species at Faringdon, and its apparent absence suggests that the 'Sponge-gravels' may be older than the beds containing this fossil in Kent and at Speeton, though its rarity anywhere in the south of England should perhaps forbid us laying much stress on its absence in this particular locality.

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[1] See my paper "On the Speeton Series in Yorkshire and Lincolnshire," Quart. Journ. Geol. Soc., vol. lii (1896), p. 181; and notes on the Hythe Beds in Annual Summary of Progress of Geol. Survey for 1897, p. 129.

On the evidence of the Faringdon *Belemnites*, then, we may conclude that the 'Sponge-gravels' are probably equivalent to the lowermost portion of the Lower Greensand Series of south-eastern England; and I am not aware of any facts adverse to this conclusion either in the other components of the fauna or in the stratigraphical position of the deposit. I hope hereafter to discuss the relations of the Faringdon Beds to other fossiliferous portions of the Lower Greensand of the Midland counties.

VIII.—QUARTZ DYKES NEAR FOXDALE, ISLE OF MAN.[1]

By J. LOMAS, A.R.C.S., F.G.S.

IN the neighbourhood of Foxdale, Isle of Man, and especially on Granite Mountain, the ground is strewn with numerous blocks of quartz. Many of them are of large size, 10 feet or more in diameter.

On the slopes of South Barrule similar blocks are found in great profusion, and they can be traced across the hills to the west coast. North of Foxdale other bands are found, some of which are inserted in the geological map. They lie principally in the altered slates of the Barrule Series, and have a general trend corresponding with the main axis of the island, from north-east to south-west. In places they are seen to be *in situ*, and where the granite mass of Foxdale intervenes the general direction changes, and is principally tangential to the intrusion.

Numerous micro-granite dykes extend along the axis of the island in the same direction.

In an old quarry at Renshent on the north margin of the granite several quartz veins are seen to traverse the granite itself. They can be traced along the floor of the quarry and up the vertical face about 30 feet high.

One of these, about 3 feet in width, shows perfectly sharp margins when cutting through the granite, dips at 65° W., and strikes 10° E. of S. It consists mainly of quartz, some clear and some white and opaque, but on entering the granite it changes locally to a pegmatite. The pegmatite contains, in addition to the quartz, large felspars, some over 3 inches long, perfectly formed, and showing crystal faces, and mica in crystals over an inch in diameter. The granite outside the vein shows the normal features of the medium-grained Foxdale type.

Under the microscope the clear quartz of the vein is seen to consist of one crystal, all parts of the field extinguishing at the same angle. The white opaque parts behave optically in the same manner, but numerous bubbles containing liquid are contained, and these, no doubt, give rise to the opacity. The inclusions are mostly in lines, and sometimes take the form of negative crystals, the principal axes of which are parallel to the cross wires when extinction takes place.

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[1] Read before the Liverpool Geological Society, November 11th, 1902.

little to the east of the quarry is a larger quartz vein about feet wide, which has been worked, and good exposures are ible. The quartz has exactly the same characters as that already scribed, and the vein can be traced as a feature and by occasional crops to Windy Common, above Cloughwilly, a distance of over a le. Here several cuttings have recently been made, which show large blocks on the surface to be *in sitû*. One of these has wed to be 30 feet wide; it cuts through altered slate containing merous needles of epidote, and is accompanied on the east side by nicro-granite dyke.

Another cutting further to the west and almost on the summit of knoll known as Granite Mountain, reveals a vein of quartz, eet wide and dipping 65° E., contained in walls of much altered ite.

At Whallag, under South Barrule, 4 miles south-west of Renshent, ground is strewn with quartz blocks which lie in great profusion the moor. Across one of the larger masses a trench has been t to prove its extent, and it is found to be *in sitû*, and forms part the series of veins which traverse the slates.

A little gulley cut by a stream near the Farm Reasch reveals her quartz veins of smaller extent, and a small micro-granite dyke t shown on the geological map.

Dealing first with the Windy Common vein above Cloughwilly, the cutting it is seen to consist of white opaque quartz with joints nning transversely, forming horizontal columns. The joints are re numerous at the margins than in the middle, reminding us of nilar features seen in basalt dykes. On the broken faces white ica is often found. Under the microscope it is seen to be indis- guishable from the quartz contained in the pegmatite. The liquid closures and negative crystals are perhaps more numerous, but all e quartz of the slide is orientated in the same direction, and tinction takes place in all parts at once. In this rock there is no gn of shearing.

The 8 ft. dyke on the summit of Granite Mountain differs only om the one just described in exhibiting traces of incipient shearing. here has been no displacement, but cracks divide the crystal to lenticular areas, leaving the whole in optical continuity. The nes of bubbles are quite independent of the cracks.

At Whallag almost exactly the same features occur, and fragments altered slate up to 5 or 6 inches in diameter are sometimes included the quartz.

Further to the south-west, and in the same general direction, the ates of the coast, as at Fleshwick Bay, contain quartz bands. They e folded and twisted with the slates, and often separated into nticular bands. A slice from one of these bands shows under the icroscope quartz of exactly the same character as those described, it shearing has gone on to such an extent that actual displacement s taken place.

Along the lines of movement a fine quartz mosaic has been rmed, but the units which have moved are simple crystals.

Under crossed nicols the mosaic is seen to consist of areas of uniform extinction, and the included bubbles bear no relation to the lines of shear.

We are here forced to conclude that the parts have once been continuous, that the liquid inclusions are original features, and that they are portions of veins which have been disconnected by earth movements.

If the quartz, when traversing the granite, is of igneous origin, and the formation locally of a pegmatite is proof on this point, we cannot deny a similar origin to the quartz occurring as veins in physical continuity with that in the granite.

There is *a priori* no reason why quartz should not exist as an igneous rock. Given a magma with a limited amount of bases, combinations would go on until the silica had united with all the bases available, and then a residuum would be left which on consolidation would be pure quartz.

A comparison might be made of these veins with the Pfahl of Bohemia, where quartz occurs as veins through the granite and mica-schists, extending in unbroken sheets over a distance of 55 kilometers. Gümbel, however, has shown that the Pfahl is associated with displacement, and he regards the quartz as filling up cracks after faulting. In the Isle of Man, I am inclined to look upon the veins as true igneous dykes, running parallel to the micro-granite intrusions, and only differing from them in their exceptional composition.

IX.—The Term 'Hemera.'

By A. J. Jukes-Browne, B.A., F.G.S.

In the December number of this Magazine Mr. Buckman complains that the use of his term *hemera* has been widely misunderstood. He says that it was never intended to be used for a subdivision of a zone, but solely as a chronological term to indicate the time during which the beds composing a *zone* were deposited, just as the term *age* is now generally accepted in a technical sense to mean the time during which a stage was deposited.

As one of those who must plead guilty to having misunderstood Mr. Buckman, I should like to explain how it is that he seems to have laid himself open to misapprehension. To put it briefly, Mr. Buckman, in his original paper of 1893, used the term *hemera*, not merely as a chronological term (though he defined it as such), but also as serving to represent a subdivision of a zone; for in two of his tables he used it as a stratigraphical division, and consequently it is his own fault if others supposed he meant it to be used in a stratigraphical sense, in spite of his own words about its chronological meaning.

That this was the immediate effect of his paper is proved by the report of the discussion upon it, in which the President spoke of "subzones or emata,"[1] and Mr. Winwood protested against the proposed term, saying that "if Mr. Buckman found it necessary to subdivide his zones in that typical district, might not 'horizon' or 'subzone' answer his purpose equally well." [1]

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[1] The word originally suggested was *emar*, subsequently altered to *hemera*.

What Mr. Buckman had really felt the want of was unquestionably a term to express a subdivision of a zone; others also have felt that want, and would have been grateful to Mr. Buckman for a handy word applicable in a strictly stratigraphical sense. Instead of this, however, he proposed a time-word, and further complicated the matter by saying that "it is for a palæontological purpose similar to Moore's use of zone that I propose the term hemera," having just above stated that Moore confined his use of the word zone "to the exact horizon of a particular fossil" (op. cit., p. 481). From this anyone might conclude that the term hemera was meant to indicate both a palæontological horizon and the time of its formation, especially as he does not use any other term for his stratigraphical unit except the phrase "strata of the hemera." Moreover, in his correlation table facing p. 514, he gives the vertical succession of beds at different places, and numbers them according to a vertical succession of hemera given in parallel columns: what is this but a use of the term hemera as a stratigraphical unit?

Again, on p. 519 there is a table entitled "Correlation of the Zones and Hemeræ," in which the latter are clearly shown to be equivalent to parts of a zone. On p. 481 of the same paper he accepts the word zone as "the stratum or strata characterized by an assemblage of organic remains"; hence it is clear that he did not use the word zone as a division of time, but of vertical thickness. Now if hemera are parts of a zone they are stratigraphical units, not time-units; what, then, becomes of Mr. Buckman's assertion that he proposed the term hemera to denote the time occupied by the formation of a zone?

Mr. Buckman says that "much of the trouble about zones and hemeræ has arisen from attempts to make the term 'zone' a kind of 'portmanteau word,' one into which several meanings were to be packed," but his further proposals would only, in my opinion, make things worse than they are now. By general consensus, as I have shown elsewhere, a zone in its geological sense is a stratigraphical term, and a subzone is a subdivision of a zone, so that we do not want the word 'hemera' in that sense, and I do not think that the term *subfaunizone* would meet with acceptance.

The term hemera may, however, be occasionally convenient to signify the duration of a subzone, as age signifies the duration of a stage, but if we want to avoid confusion we must not speak of the hemera of a zone. For this another word should be coined, and if one is really necessary I would suggest that the Latin word *seculum* will furnish us with 'secule,' which finds an actual French equivalent in *siècle*.

I submit, therefore, that the awkward words 'biozone' and 'faunizone' are quite unnecessary, and certainly do nothing to dispel the ambiguity in the meaning and use of the term 'hemera.' I think that all requirements would be met by the use of the following terms, which simply extend the accepted geological scale into more minute units of thickness and time. Thus—

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[1] Quart. Journ. Geol. Soc., vol. xlix, p. 522.

A *stage* represents an *age.*
A *zone* represents a *secule.*
A *subzone* represents a *hemera.*

Mr. Buckman's use of the term hemera with the specific name of a fossil in front of it may very well be adopted as a shorter phrase than the full expression of the subzone; thus we may write of the '*concavi*-hemera' as short for the "hemera of the subzone of *Lioceras concavum*," but the stratum containing this Ammonite is a subzone, not a hemera nor a zone.

REVIEWS.

MÉMOIRES POUR SERVIR À L'EXPLICATION DE LA CARTE GÉOLOGIQUE DÉTAILLÉE DE LA FRANCE. (*a*) RECHERCHES SUR LA CRAIE SUPÉRIEURE (première partie), par A. DE GROSSOUVRE, avec (*b*) une monographie de genre *MICRASTER* par J. LAMBERT. 4to; in two Fasciculi with 1,013 pages, 33 figures and maps, and 3 plates. (Paris, 1901.)

THOUGH both the fasciculi of this work bear the date 1901 they do not seem to have been distributed until 1902. The scope of the treatise is considerable, for under the title of "Craie Supérieure" the author includes the Turonien, Senonien, and Maestrichtien divisions of the Chalk throughout western and central Europe, with chapters on the Chalk of India and the United States. These are followed by an essay on the classification of the Upper Cretaceous Series, and by another on the History of the Earth with especial reference to that of Cretaceous Time. Moreover, some space is devoted to a monograph on the genus *Micraster* written by M. J. Lambert.

It is evident, therefore, that in these volumes we have the results of a detailed and comparative study of what has been discovered and written about this portion of the Cretaceous System, not only in France but in many other countries. The work does indeed furnish the reader with an enormous amount of information, the greater part of which is a careful compilation from the most authoritative sources available at the time of writing; each chapter contains one or more tabular correlations of the strata described therein, and also tabulated lists of the Cephalopoda and Echinoderms showing the vertical distribution of each species.

Moreover, in those chapters which call for the exercise of original thought and the critical faculty we are pleased to find that M. de Grossouvre is a careful balancer of evidence, that he seldom takes an extreme view on any debateable question, but generally takes a comprehensive grasp of its several aspects. Consequently his opinions and conclusions deserve serious consideration, whether they happen to fall in with the reader's views or not.

The treatise will undoubtedly be useful to every student of the Cretaceous System, though of course some portions are of less value than others, and it suffers as a whole from the fact that its component parts have been printed off in successive years from 1895 to 1901. The author states this in order to explain his omission to notice the numerous publications on the Chalk which have appeared since the earlier chapters of his monograph were printed off. Thus the account of the Chalk of England and Ireland which forms Chapter v is much behind the knowledge of the day; it is short and taken almost entirely from Prof. Barrois' "Recherches" (published in 1876), which was excellent at that date, but has since been corrected and improved upon in many particulars. A great thickness is attributed to the zone of *Marsupites*, while that of *Actinocamax quadratus* is said to be little developed in England, the fact being that the greater part of Prof. Barrois' zone of *Marsupites* is really referable to the zone of *Actinocamax quadratus*.

The Chalk of France (i.e. the Turonian and Senonian stages) is described in considerable detail, separate chapters being given to the following areas: the Paris Basin, Hainault and Limbourg, Touraine, Aquitaine, the Pyrenees, the valley of the Rhone, Provence, and the Western Alps. The chapter on the Paris Basin, however, does not include any adequate account of the Chalk of Normandy, which indeed is hardly mentioned; the reason of this is that since Hébert's time no French geologist has examined the fine chalk cliffs of Fécamp, St. Valerie, and Dieppe, that consequently the materials for a zonal description of this area do not exist, and M. de Grossouvre has been obliged to omit it from his purview. It is to be hoped that he or some other capable geologist from France or England will ere long make good this regrettable hiatus in our knowledge of the Chalk of the Anglo-Parisian region.

Other chapters deal with the Chalk (generally including the Cenomanian) of the Central Alps, the Eastern Alps, Bavaria, Bohemia, North Germany, Scandinavia, India, and the United States.

Besides these there are four chapters which discuss questions of general interest, and there is M. Lambert's essay on the genus *Micraster*. Of these chapters I propose to give some brief review.

Chapter i deals with stratigraphical methods and need not detain us long. In it the author states his dissent from the method generally employed in the correlation of strata, and especially of zones, i.e., the method of comparing assemblages of characteristic fossils including species of many different kinds of animals. This, he says, has led to many errors, and after reviewing various animal groups he concludes that Cephalopoda, and especially the Ammonoidea, are the only group that provides us with a sufficiently rapid succession of forms to furnish a dependable chronometric scale. "The method to be followed should be the same as in the Jurassic System, to begin with a chronometric scale based on the succession of Ammonite faunas, then by a comparison of a sufficient number of sections in different regions to establish the correlation of the beds in which Cephalopoda do not occur."

Chapter ii is entitled "Des Conditions de dépòt de la Craie Blanche." He refers to the antagonistic opinions which are held upon this subject, some considering the Chalk to be a deep-water pelagic deposit, and others maintaining that it was formed in comparatively shallow water and not far from land. He constructs a table of the successive kinds of deposit which would normally be formed in an area which underwent extensive subsidence until it was covered by very deep water and then slowly rose again, and he shows that Cretaceous deposits found in the Paris Basin correspond with such a succession, that each stage indicates deeper water than that below, till in the Chalk with many flints we have a deposit formed in water of more than 500 metres and at a great distance from shore-lines.

He next examines the minute structure of Chalk, the Chalk fauna, and the composition of flints, quoting the opinions and observations of many authors. He concludes that white chalk must have been deposited in the central parts of a very extensive sea, the deepest part of which may have been about 1,000 metres (546 fathoms).

Chapter iv is M. Lambert's essay on the genus *Micraster*, but it is not easy to see why this should have been included in these volumes, which are described as the stratigraphical part of a more complete treatise. Moreover, since M. de Grossouvre relies mainly on Ammonites for his zonal classification one would have expected an essay on them rather than one on the Micrasters.

M. Lambert enumerates a large number of species, and considers between 30 and 40 of them to be good species, though not all of these occur in the Anglo-Parisian basin. He describes the species in the order of their creation, and not in the order of their affinities. He does not indicate the characters which he considers to be of specific importance, but seems to rely mainly on differences in general shape, in the characters of the ambulacral areas, and in the clearness of the subanal fasciole. He does not recognize the importance of the peristome, the labral plate, the tip of the labrum, and the periplastronal area, on each of which Dr. Rowe lays stress.

The general classification of the Upper Cretaceous Series occupies a long chapter. A preliminary discussion of principles leads the author to take D'Orbigny's names for his primary divisions or stages. and he also adopts most of Coquand's sub-stages, finally indicating what zones he would include in these several sub-stages. The indices of his zones are throughout species of Ammonites, and he expressly states that if Echinids were taken as guides the zones would not be the same.

Dealing first with the Cenomanian, he has necessarily to fix the limits of the stage, and more especially its lower limit. This, as he remarks, is a question which has often been debated, and which has recently been the subject of controversy between myself and M. G. Dollfus. After reviewing the difficulties the author decides in favour of the view which I have maintained; he puts aside the argument of the Cenomanian transgression as valueless, and while admitting that there are some localities where beds of passage exist and where "hesitation is admissible," he continues: "but this is not the case in the north of France, and if as a basis of classification one relies entirely on the succession of Ammonite faunas, putting all other fossils aside, the gaize of Havre and that of Argonne will necessarily be excluded from the Cenomanien."

With regard to the upper limit of the stage, he says that it is almost everywhere clearly indicated by the disappearance of the *rotomagensis* group of the genus *Acanthoceras* and their replacement by the *ornatissimum* group, as well as by the appearance of *Pachydiscus peramplus* (which he refers to the genus *Neoptychites*). By this criterion he places the subzone of *Actinocamax plenus* in the Turonian, because M. Lambert has found *Pach. peramplus* in it at Dracy (Yonne), but in England *Acanth. rotomagensis* has been found in it and *Pach. peramplus* has not, so that by the same criterion we do right to retain the Belemnite marl in the Lower Chalk (Cenomanian).

For the Turonian he accepts D'Orbigny's definition of that stage in Touraine as including all the beds between the Cenomanian and the 'craie de Villedieu.' As the base of the latter appears to lie somewhere in what is usually called the zone of *Micraster cortestudinarium*, it is evident that, according to D'Orbigny and De Grossouvre, the Turonian should comprise the beds which have hitherto been known in France as the zones of *Inoceramus labiatus*, of *Terebratulina gracilis*, and of *Holaster planus*, with a portion of the zone of *Micraster cortestudinarium*. M. de Grossouvre, however, takes the Ammonoidea as his zonal guides, and divides his Turonian into four zones, which are grouped under two sub-stages thus:—

Turonien	Angoumien	zone of	*Acanthoceras Deveriæ.*
		„	*Acanthoceras ornatissimum.*
	Saumurien	„	*Acanthoceras Bizeti.*
		„	*Mammites nodosoides.*

In the Senonian M. de Grossouvre groups all the higher Cretaceous beds which are found in France, and he divides the stage into two large sub-stages for which he adopts the names *Corbiérien* and *Campanien*, the former corresponding mainly with the zones of *Micraster coranguinum* and *Marsupites*, the latter with the zones of *Actinocamax quadratus* and *Belemnitella mucronata.* He regards the Maestrichtien of Belgium as only a facies of the craie de Meudon, and the Dordonien of Aquitaine as another facies of about the same age, so that both these divisions are brought within the limits of his Campanien.

Finally, he excludes the 'calcaire pisolitique' of France and the limestones of Saltholm and of Faxe from the Cretaceous system, on the ground that they contain no Ammonites. He places them, with the Montien of Belgium, as the basal portion of the Tertiary succession, though he hesitates to call them Eocene. In this he follows the Geological Survey of Belgium, who have created a 'Palæocene System' for their Montien, but it is generally admitted that the typical Danien is older than the Montien, and for myself I fail to see that the absence of Ammonites is a sufficient reason for excluding the Saltholm and Faxe beds from the Cretaceous system.

Returning to M. de Grossouvre's classification of the Senonian, there can be no doubt that he avoids some difficulties by taking

Cephalopoda alone as his guides, and in creating eight Ammonite zones in place of those usually adopted. Where species of Ammonites occur with sufficient frequency, these zones are no doubt more satisfactory than those based on Echinoderms, but it will be some time before they can be made practically applicable to the Upper Chalk of England, in which Ammonites are rare fossils. If they are ever adopted in this country it will only be after they are firmly established in the north of France, and after a more careful comparison of our Chalk with that of the Paris Basin.

M. de Grossouvre's final chapter on the History of the Cretaceous Period deals with nearly the whole of the Northern Hemisphere, and discusses the general distribution of land and water which existed in late Palæozoic and in Mesozoic times. It should be read by all who are interested in this subject, but the author's views and conclusions can hardly be summarized in a few lines.

A. J. JUKES-BROWNE.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 5th, 1902.—Prof. Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. From the Right Hon. the Secretary of State for the Colonies:—

"CURATOR, Botanic Station, St. Vincent, to IMPERIAL COMMISSIONER OF AGRICULTURE for the West Indies.

"Botanic Station, St. Vincent.
September 5th, 1902.

"SIR,—Cable communications of the eruption of the Soufrière on the 3rd and 4th inst. have doubtless reached you; nevertheless, I deem it my duty to forward you by this the earliest opportunity an official report on same:—

"Early on the afternoon of the 3rd inst. telephonic communications reached me that the Soufrière was agitated, and from the Botanic Station at about 2 p.m. on that day I observed certain white and dark clouds in the direction of the Soufrière, which from their upward movements convinced me that an eruption of the Soufrière was near at hand. At 3 p.m., the hour of taking observations at the Botanic Station in the afternoon, the corrected barometrical reading was 29·947 and the attached thermometer 85° F. The wind was blowing lightly from the north-east and the weather was bright. The only clouds were to the north, and the most conspicuous was a dark brown column, apparently over the Soufrière. At 5.30 p.m. I had a conversation with Mr. Nairn and Mr. Frederick at Montrose, and from the then appearances and sounds we were convinced that an eruption was pending. At about 8 p.m. I met in Kingstown Mr. H. Allen, Revenue Officer at Châteaubelair, who informed me that during the day he saw a lot of matter ejected over the western lip of the old crater down the Laricor or Roseau Valley to the sea. Mr. Allen and most of the residents of Châteaubelair left that place late in the afternoon for places of safety, and in the Georgetown District (Windward) the residents moved southward. At 9.55 p.m., as seen at the Botanic Station, the eruption commenced in earnest; flashes of flame and lightning were visible over the Soufrière at intervals of 20 to 30 seconds, with frequent longer intervals. At 10.30 p.m. the corrected reading of the mercurial barometer was 30·105 and the attached thermometer 81°·5 F. From about this hour the discharges and accompanying noises increased in frequency and severity, and at 1.30 a.m. (4th) the Soufrière was in full eruption. From this hour to 2 a.m. the eruption was, in the writer's opinion, more severe than on May 7th; the explosions seeming to be louder and more continuous, and the electric discharges, owing doubtless to its being night, immeasurably grander and more awe-inspiring. The writer's house vibrated in a manner it did not do on May 7th. At 2 a.m. the corrected barometrical reading was 30·045 and the temperature 81° F., and at 3 a.m. the corrected reading was 30·035. The marvellous electric display was checked by a heavy shower from the east, and the roar was correspondingly lessened. From about 1·30 a.m. a cloud black as gunpowder was seen advancing southward from the Soufrière, and at 2·30 this cloud had assumed a circular form and was overhead of the Botanic Station. The discharges from this cloud and to northward were exceedingly numerous and severe, and the appearance generally was as though myriads of long fiery serpents were darting hither and thither, and a constant cracking noise was heard, in addition to the roar of the volcano. The chief disturbances seemed to be west of the Soufrière, in the direction of Martinique; and the writer is strongly of opinion, from observations at the time, that Mont Pelé and the Soufrière were in action together, but so far no news has come from Martinique. At 3 a.m. (4th) the discharges and roar to the west nearly subsided, and the Soufrière alone seemed in action, but more on the Windward side. From 3 to 4 a.m. the eruption gradually slackened, and at the latter hour had nearly ceased. The next morning the barometer was normal at 29·950, but the morning had a weird and gloomy appearance. No ashes or pebbles fell at the Botanic Station. No deaths are reported anywhere, and no damage to Windward, but to Leeward I learn on good authority that places partly untouched on May 7th are now very severely injured—for instance, the arrowroot-fields at Richmond Vale and Petit Bordelle and Sharpes, as well as the sugar-canes at the first-named, are extensively damaged by the thick coarse layer of material, and as far down as the Linley Estates and Cumberland extensive damage to ground provisions and arrowroot is reported. The principal peasant allotments are on the Linley Estates, and early to-morrow morning (6th) I am going with Mr. Osment to inspect these erstwhile thriving places. His Honour the Administrator is also visiting the Leeward District as far as Châteaubelair to-morrow. We had made arrangements for distributing some thousands of economic plants to the Leeward allottees during the coming week, but I fear that this is now out of the question, as the holders have reported that their provisions are buried deep. Last night we had one of the worst thunderstorms experienced here during the last 12 years, though the rainfall was only ·44 inch. I enclose for your further information a copy of the *Times* newspaper, so far the only one issued this week, and on my return from Leeward I hope to be able to give further facts.

"I have, etc.
(Signed) H. Powell,
Curator.

"Dr. D. Morris, C.M.G.,
Imperial Commissioner of Agriculture
for the West Indies."

2. A second communication (also received through the Secretary of State for the Colonies) was read, dated Grenada, September 23rd, from Sir R. B. Llewelyn, Governor of the Windward Islands, expressing the hope that some scientific observers might be induced to go out to the West Indies and settle there for some time, in order to accumulate information as to volcanic and kindred phenomena.

3. "The Fossil Flora of the Cumberland Coalfield, and the Palæobotanical Evidence with regard to the Age of the Beds." By E. A. Newell Arber, Esq., M.A., F.G.S.

The succession of Upper Carboniferous rocks in the region in question is apparently twofold: an essentially arenaceous series, at least 600 feet thick, consisting of massive sandstones alternating with shales and fireclays, overlying argillaceous and carbonaceous deposits; the latter forming the productive portion of the coalfield and containing three great coal-seams, traceable throughout the district, although known locally under different names. The Upper or Sandstone Series has yielded very few plant-remains from its upper division, but from the lower division a long list is given of plants collected by the author or preserved in the Woodwardian Museum. A second list of plants, from the upper division of the Carbonaceous Series, is also given, nearly all the specimens having been collected by the author. The consideration of the palæobotanical evidence enables him to classify the rocks as follows:—

Permian.	Brockram.		Lower Permian.
Upper Carboniferous	Sandstone Series.	Upper	(?) Transition Coal-measures
		Lower	Middle Coal-measures.
	Productive measures.	Upper (Bannock and Main Bands).	
		Lower (?)	(?) Lower Coal-measures and Millstone Grit.

4. "Some Remarks upon Mr. E. A. Newell Arber's Communication: On the Clarke Collection of Fossil Plants from New South Wales." By Dr. F. Kurtz, Professor of Botany in the University of Córdoba, Argentine Republic. (Communicated by A. C. Seward, Esq., M.A., F.R.S., F.G.S.)

The author agrees with Mr. Arber's identification of *Rhiptozamites Goepperti*, which he takes to be a synonym of *Noeggerathiopsis Hislopi*. *Podozamites elongatus*, however, he regards as different from *Noeggerathiopsis Hislopi*. Reasons are given for holding this opinion. Further, the author does not consider that there is sufficient evidence to warrant the separation of *Otopteris ovata* from *Rhacopteris inæquilatera*, in which species it may be retained, perhaps, as a variety. *Rh. inæquilatera* has been found in the Argentine, and was described by Geinitz as *Otopteris Argentina*. A bibliography is appended.

5. "On a new Boring at Caythorpe (Lincolnshire)." By Henry Preston, Esq., F.G.S.

This boring, after piercing Northampton Sands, passed through 199 feet of Upper Lias, 19 feet of Marlstone, and into the Middle Liassic Clays. With the aid of other shallow wells in the Lincolnshire Limestone the author shows that this rock has a decided dip to the west down the face of the escarpment, as though it had settled down upon the eroded surface of the Upper Liassic Clay. This settlement is probably the cause of a continuous spring flowing from the junction, and it has given rise to an underestimate of the thickness of the Upper Lias.

II.—November 19th, 1902.—Prof. Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Semna Cataract or Rapid of the Nile: a Study in River-Erosion." By John Ball, Ph.D., F.G.S., A.R.S.M., Assoc. M. Inst. C.E.

Inscriptions placed on the rocks at Semna, between the second and third cataracts, under the Twelfth and Thirteenth Dynasties, serve as a means of gauging the local changes due to river-erosion during a period of about 4,200 years. Horner, in 1850, came to the conclusion that "the only hypotheses which could meet the requirements of the facts observed would be either the wearing away of a reef or barrier at the place in question—a process requiring too long a period—or the existence at some distant period of a dam or barrier, formed perhaps by a landslip of the banks, at some narrow gorge in the river's track below Semna." The author is in favour of the former explanation. The river, above and below the Kumna and Semna temples, has a width of 400 metres, but between the two temples a narrow band (200 metres wide) of hard red and grey gneiss contracts the river at low Nile within a central channel about 40 metres wide. Through this deep channel not less than 400 cubic metres of water pass per second. The gneiss itself, dykes of syenite-porphyry, hornblende-schists, and augitite are described; and it is shown that the foliation of the gneiss is parallel to the channel, and probably accounts for the direction of the latter. Rapid erosion with the formation of pot-holes is observed to be now taking place; and the author calculates that if 200 cubic metres (approximately 500 tons) of rock per year has been removed from the barrier, the lowering of it would amount to 2 millimetres a year, or in 4,200 years 7·9 metres, the depth of the present river below the lowest group of inscriptions dating from the time of Amenemhat III. The yearly discharge of the Nile past Semna is nearly 100,000 million tons of water; and the author considers that the removal of 500 tons of rock under existing conditions in a year is not only not impossible, but highly probable, as all this erosion only amounts to 5 milligrams of rock per ton of silt-laden water. This erosion is compared with the classic instance of the River Simeto in Sicily. At Assuan and Silsilla the river has suffered considerable lowering within geologically recent times, probably brought about by the removal of long pre-existent hard barriers. The sluices of the new dam at Assuan may in the future give a quantitative determination of silt erosion in granite, and it would appear to be not difficult to ascertain at Semna the rate of pot-holing. The formation of new pot-holes 1½ feet deep, in an artificial channel in rock in Sweden, has been observed to take place in 8 or 9 years, and the author hopes in future to attempt some measurements of this kind at Semna.

2. "Geological Notes on the North-West Provinces (Himalayan) of India." By Francis J. Stephens, Esq., F.G.S., A.I.M.M.

The country examined extends in a north-westerly direction across the line of strike, from the borders of Nepal and South-Eastern Kumaon to north of the Alakmunda River in the vicinity of Badrinath and the Marra Pass. The foothills consist of Tertiary clays and sandstones, the snowy ranges of gneissose, granitic, and metamorphic rocks of various descriptions. "Between the snowy ranges, or, rather, the most southerly range of the Himalaya chain, a band of hills extends, for nearly 50 miles on an average, to the foothills." These have hardly been explored, though roughly mapped on geological maps of India as belonging to a "Transition Series." The whole area is rich in minerals. The author gives a brief description of various rocks, met with mainly in this third belt. They include slates with vein quartz; mica and graphite schists; dykes of dolerite; granites; clay-slates, sandstones, and schists, with copper, lead, and tin; limestones, serpentines, and hornblendic rocks, with talc, steatite, etc.; various schists, quartzites, and limestones. The summary of the author's observations leads him to "suppose that there are at least three distinct limestone or calcareous series in Kumaon and Garhwal, and that schists and quartzites, with several isolated patches of granitic rock, form a large part of the remaining formations."

3. "Tin and Tourmaline." By Donald A. MacAlister, Esq., F.G.S.

Cassiterite hardly ever occurs without tourmaline, though the latter is found without the former; hence it appears that tourmaline-producing constituents and influences are of wider range than are those of cassiterite. Boron-trioxide is an extremely common accompaniment of volcanic action, and there can be no doubt that it has acted powerfully in changing such original minerals as the micaceous and felspathic ingredients of crystalline rocks. From a comparison of formulæ representing tourmaline and felspar, it is evident that the act of tourmalinization has been accompanied by a loss of soda. The excess of this soda will combine with boric acid, forming metaborate and pyroborate of soda. The former, acting on disseminated tin-ore, might result in the production of sodium-metastannate and borax. The metastannate is soluble and capable of being leached out of the magma, and, by a new reaction, tin-oxide may be precipitated and concentrated, while sodium-metaborate may be liberated. According to the cooling-curve of solutions, in all probability deposition of the oxide of tin would take place more rapidly at a certain stage in the process of cooling than at others.

OBITUARY.

THE REV. THOMAS WILTSHIRE, M.A., D.Sc., F.L.S., F.G.S., F.R.A.S.,

EMERITUS PROFESSOR OF GEOLOGY, ETC., KING'S COLLEGE, LONDON.

BORN APRIL 21, 1826. DIED OCTOBER 27, 1902.

THOMAS WILTSHIRE was born in the City of London 21st April, 1826, and was the son of Mr. Sampson Coysgarne Wiltshire and of Sarah his wife (*née* Sarah Goodchild). He was educated at home by a private tutor, Mr. Burtt, and spent much of his spare time when a boy, as well as his pocket-money, in technical pursuits, being very skilful in all mechanical work and in the use of tools and apparatus of all kinds. He afterwards commenced as a student at

King's College, London, but at 19 he entered Trinity College, Cambridge, where he did well in Classics and Mathematics. Here, attending Professor Sedgwick's lectures, he developed a taste for geology, which continued to be the dominating pursuit of his after life. In 1849 he was duly elected on the Livery of the 'Clothworkers,' to which City Company he had been apprenticed seven years previously. He took his B.A. degree with honours on the 26th January, 1850, and in the following June was ordained a Deacon and became Curate of Riddings, Derbyshire. On the 22nd October, 1850. the young Deacon married Miss H. Hudson. His eldest son—Thomas Pemberton Wiltshire—was born on November 15th, 1851.

He took his M.A. degree in July, 1853, and on the 18th December of that year he was ordained a Priest. In 1855 the Rev. Thomas Wiltshire was appointed Sunday Evening Lecturer at the united parishes of St. Matthew's, Friday Street and St. Peter's, West Cheap. For many years he spent his Summer holidays at Folkestone, where he assiduously collected the fossils of the Gault and Grey Chalk, assisted in his labours by Griffith, the well-known collector. In other years he stayed at Niton and Ventnor, in the Isle of Wight, collecting from the Hard Chalk, Chloritic Marl, and Upper Greensand with Mr. Mark Norman; or working at the Red Chalk of Hunstanton with Westmoreland, the old lighthouse-keeper, or at the Chalk of Filey, in Yorkshire. From these historical localities, either with his own hands or aided by the local collectors, and likewise from that well-known old explorer of the Upper Chalk of Bromley, Kent, Jeremiah Simmonds, Mr. Wiltshire gradually accumulated a very fine collection of Cretaceous fossils, which about five or six years ago he presented to the Woodwardian Museum, Cambridge, where they are now preserved, together with the portrait of the donor.

In 1856 Mr. Wiltshire took his first scientific degree, by being elected a Fellow of the Geological Society of London, and in that year he, with other members, presented an address from the University of Cambridge to Her Majesty Queen Victoria at Buckingham Palace.

In 1857 he opened the first Sunday-school in the City of London at St. Nicholas Cole Abbey. On February 8th, 1859, Mr. Wiltshire was elected President of the newly-formed Geologists' Association, in succession to Toulmin Smith, Esq., its first President and one of the founders of the Association, which now numbers nearly 600 members, and was one of the first scientific societies to admit lady members and to accord to them equal privileges with the male sex. He was elected a Fellow of the Royal Astronomical Society in 1860, and of the Linnean Society in 1861. On the 4th April, 1859, Mr. Wiltshire read an excellent paper "On the Red Chalk of England" (see Proc. Geol. Assoc., vol. i, 1859–1865, p. 3, and *Geologist*, vol. ii. July, 1859, pp. 214 and 261–278). Mr. Wiltshire remained President of the Association from 1859 to 1862, and was re-elected and served from 1871 to 1873, when he was succeeded by Dr. Henry Woodward, F.R.S. In January, 1862, Mr. Wiltshire read a paper "On the Ancient Flint Implements of Yorkshire, and the modern fabrication of similar specimens" (see Proc. Geol. Assoc., vol. i, pp. 215–226).

His friend Dr. J. S. Bowerbank, F.R.S., relinquished the Secretaryship of the Palæontographical Society in 1863, which he had held for 15 years, and the Rev. T. Wiltshire, M.A., F.G.S., was appointed in his stead, an office which he held until 1899, a period of 36 years, when he was followed by Dr. A. Smith Woodward, F.R.S. Mr. Wiltshire was also elected Secretary of the Ray Society in 1872, and continued to hold that post up to the time of his death. On his retirement from the Palæontographical Society, the two Societies presented him with an illuminated address, executed by Miss G. M. Woodward, his portrait in oil, by Miss Atkinson, and a cheque.

From his first home in Brompton he removed with his family to the Rectory, Bread Street Hill, E.C., in 1864, where he resided till about 1869, when, on its demolition, for City improvements, he migrated to 25, Granville Park, Lewisham, where he remained up to his death. In 1872 he acted as Lecturer in Geology for Professor Tennant at King's College for eight years. In 1880 Mr. Wiltshire filled the office of Dean for Evening Instruction; and on Professor Tennant's death in 1881 he was appointed Assistant Professor, and in 1890 Professor of Geology and Mineralogy, a post which he held until 1896, when upon his retirement. he was duly elected a Fellow and Emeritus Professor of King's College.

Mr. Wiltshire was one of the Honorary Secretaries of the Geological Society in 1874, an office which he filled until 1878. In 1882 he was selected for Treasurer to that Society, a post which he continued to hold until 1895, a period of 13 years.

In 1888 (following the order of succession after his election to the Livery in 1849, a period of 39 years) he became Master of the Clothworkers Company, the fifth most opulent Company in the City of London. Not only during his year of office, but when serving on the Court of Assistants, he frequently selected his geological and scientific associates to be the guests of the Company. He also assisted in distributing its numerous Charities.

After Mr. Wiltshire ceased his geological work, he spent his vacations in visiting Algiers, Iceland, Norway, and the Swiss Alps. In Switzerland, indeed, he spent several of his long Summer vacations. On four occasions he went to North America, taking in Canada, the United States, the Yellowstone Park, and the Rocky Mountains. On 27th April, 1899, the University of Cambridge conferred upon him the honorary degree of Doctor in Science (see Geol. Mag., June, 1899).

The Rev. Dr. Wiltshire performed the service and delivered his last Sunday evening lecture at St. Clement's, East Cheap, on the 26th October, returning home cheerfully to supper, his duty ended. The same night he passed quietly away from heart failure, after a busy life of 76 years. He now rests peacefully from his labours, leaving his widow, two sons and one daughter to mourn his loss.

H. W.

Albert Gaudry

THE

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ORIGINAL ARTICLES.

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I.—Eminent Living Geologists: Prof. Albert Jean Gaudry, Memb. Inst. France, For. Memb. R.S., For. Memb. Geol. Soc.

(WITH A PORTRAIT, PLATE II.)

THE recent retirement of Professor Albert Jean Gaudry, who for fifty years has been associated with the Jardin des Plantes, gives us an opportunity of presenting our readers with his portrait.

Born in 1827, he started for Cyprus and Greece at the age of 25, on what was destined to prove an epoch-making visit, for while there he obtained satisfactory information about the rich deposit of vertebrata at Pikermi, which he afterwards visited. The results of his labours are embodied in the classic "Animaux fossiles et Géologie de l'Attique" (1862–67), and a new world of vertebrate life was fully opened to zoologists, of which the first glimpse had been obtained by Wagner. But perhaps the best known of Gaudry's writings is his "Enchaînements du monde animal dans les temps géologiques" (1878), reprinted in 1895, a work which has had great influence on the younger school of thought (see Geol. Mag., 1878, pp. 221–227, and 1884, pp. 32–40).

Appointed Assistant to Professor Alcide d'Orbigny (the first to hold the Chair of Palæontology at the Jardin des Plantes) in 1853, while still in Cyprus, he succeeded Edouard Lartet in that Chair in 1872. He was Vice-Secretary of the Geological Society of France in 1852, Secretary in 1854, and President in 1863, 1878, and 1887; while in 1900 he presided over the Meetings of the Eighth International Congress of Geology, held in Paris.

Gaudry's first published works dealt with Starfishes (1852) and the Origin of Flint (1852), but soon afterwards he confined himself to Vertebrate Palæozoology, with a result that is known to even the most superficial student of the science throughout the world.

Professor Gaudry has observed that, among students of Nature of all ages, two methods of work may be noticed: the *synthetical* and the *analytical*. It is not difficult to see that he himself is more in sympathy with the former, and on the occasion of his Jubilee, recently celebrated in Paris (Geol. Mag., May, 1902, p. 240), the bent of his mind, as reflected in his writings, was dwelt upon by MM. Perrier, Boule, and Liard, the speakers on that occasion.[1]

Applause is too often readily bestowed upon speculative work, which deserves no higher praise than that of being happily conceived; at the time no one enquires whether there is any solid basis for the speculation, and the writer is often thoroughly satisfied with his temporary success. It is different with Gaudry. The real and lasting merit of his work is due to the fact that his generalizations are based upon painstaking and accurate analytical research; analysis and synthesis are happily blended, and his generalizations are the outcome of careful analytical investigation. This is not only true of his descriptive publications ("Animaux fossiles et Géologie de l'Attique"; "Animaux fossiles du Mont Léberon"), but also of those which are professedly of a more philosophical nature, and among the latter his "Enchaînements" certainly takes the first place. In this work the generalizations are not merely based on previously known data, but upon numberless original observations made known for the first time in that volume.

It should also be borne in mind that from his earliest writings Professor Gaudry, like his illustrious contemporary, Professor Rütimeyer, of Basel University, Switzerland, based his teaching on the theory of evolution, a fact which made his work, as Boule reminds us, an act of independence and courage which few men of science on the Continent were prepared to follow in those early days of Darwin's writings.

Professor Gaudry's separate contributions to palæozoology in various scientific journals numbered 85 up to 1883, but many others have appeared during the past 20 years. Among those of later years we may mention two of special importance, namely, his memoir on *Actinodon Frossardi*, Gaudry, discovered by M. Bayle in the Lower Permian, Autun, Saone et Loire, France (Nouvelle Archives du Museum, ser. II, vol. x, 1887, pp. 9–19, pl. i); and his account of the discovery and reconstruction of the entire skeleton of *Elephas meridionalis*, F. Nesti, in the Volume Commémoratif Centenaire de la Fondation du Musée d'Histoire Naturelle, Paris (4to, 1893, pp. 327–348, with plate).

Professor Gaudry was elected a Foreign Correspondent of the Geological Society of London in 1868, and a Foreign Member in 1874; and at the annual general meeting on February 15th, 1884, the President, Mr. J. W. Hulke, F.R.S., in presenting him with the Wollaston Gold Medal, the highest honour the Society is able to confer, addressed him as follows:—"Professor Gaudry, the Council of the Geological Society has awarded you the Wollaston Medal in recognition of the value of your palæontological researches and the important scientific generalizations you have deduced from long and laborious observations. The numerous papers on topographical geology and on palæontology you have contributed during the past 30 years, your important 'Recherches Scientifiques en Orient entreprises par les ordres du

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[1] "Jubilé de M. Albert Gaudry" (Paris, par le Comité, 1902).

Gouvernement pendant les années 1853–1854,' your 'Animaux fossiles et Géologie de l'Attique,' and, lastly, your work 'Les Enchaînements du monde animal dans les temps géologiques,' have made your name so familiar, wherever our branch of natural science is cultivated, that in receiving you we feel we are not receiving a stranger, but a scientific brother, and one who, by his labours and singleness of aim, has achieved a position as a palæontologist such as few can hope to attain. Personally it affords me great and sincere pleasure that it has fallen to my lot to hand you this Medal, which, by the consent of all, has never been more worthily bestowed." Later on the Royal Society recognized Professor Gaudry's merits by electing him one of its Foreign Members in 1895.

But the crowning honour of Professor Gaudry's career was reserved for the 9th March last, when his pupils, friends, and admirers assembled in the Palæontological Gallery, one of the most beautiful buildings of the Museum of Natural History in the Jardin des Plantes, to commemorate the fiftieth anniversary of his connection with the Museum by presenting to him a gold medal, designed by M. F. Vernon, bearing his portrait and name on the obverse, and on the reverse a classical female figure (to represent our science), supporting a geological pickaxe, beside which rest the skull and lower jaw of *Dinotherium*, and at her feet numerous fossil bones. In the background is a view, in low relief, of the ravine and hills at Pikermi, Greece, where Gaudry carried out his great work nearly fifty years ago. This side bears the inscription above—

"A . ALBERT . GAUDRY
PALEONTOLOGISTE
ses . Eleves . ses . Amis
ses . Admirateurs";

and beneath the figure the words

"PIKERMI . 1855–1860."

Over forty French and foreign Academies and scientific bodies either sent delegates or forwarded written addresses, and nearly 350 names of distinguished men of science of all nationalities have subscribed to the list.

Apart from his eminent scientific attainments which have rendered his name so well known and honoured as one of the leading biologists of the day, Professor Gaudry has endeared himself, not only to his pupils and colleagues, but to a very wide circle of friends and admirers, by the amiability of his disposition and the kindness of heart which he has always displayed both to friends and strangers, at all times, whenever they have approached him and sought his personal or scientific aid. Long may he live and continue to enjoy that warm regard which all feel for so amiable and kindly a man.

His former pupil and valued assistant of many years, Professor Marcellin Boule, has, we learn, been appointed as successor to Professor Gaudry, and will carry onward with him in his career the same good wishes which follow his master into his retirement.

II.—ADDITIONAL NOTE ON THE CORRELATION OF THE ROCKS ASSOCIATED WITH THE DEVONIAN LIMESTONES OF THE HINDU KHOOSH.

By Lieut.-General C. A. McMAHON, F.R.S., F.G.S.

SINCE the publication of the joint paper by Mr. W. H. Hudleston and myself on "Fossils from the Hindu Khoosh,"[1] in which the Devonian age of well-preserved fossils found in the limestone member of a series in Chitral was demonstrated, my attention has been called by Mr. T. H. Holland to the fact that the series in Chitral agrees very closely with the rocks known to the Geological Survey of India as the infra-Trias, and described, for the last time, in Hazara[2] by Mr. C. S. Middlemiss.

The Chitral series consists of three principal formations:—(1) A lower bed of conglomerate with rounded to subangular pebbles, varying greatly in size up to 3½ inches in diameter, lying in an indurated, fine-grained matrix of slaty grit or arenaceous mudstone. The pebbles consist of limestone, slates, sandstones, and quartzites, with rounded, white quartz-pebbles, which recall the 'eggs' of the Blaini conglomerate of the Simla area. (2) A middle band described by my son, who made a hurried visit to the place, as red sandstone; and (3) an upper bed of grey, dark-blue, and cream-coloured fossiliferous limestone.

In Hazara the system of rocks known to the Geological Survey as the infra-Trias, on account of its position unconformably below the Trias, consists in the same way of a lower conglomerate, a middle sandstone series, and an upper limestone formation. These rocks, originally referred to by Wynne and Waagen, were described in fuller detail by Middlemiss in 1896.[3]

According to Middlemiss, the conglomerate is composed of subangular pebbles of slates and quartzites, usually of about the size of a cricket ball, but varying from mere pebbles to larger lumps, and set in a fine purple sandy clay or shale. Like the Chitral conglomerate the bed—boulders and matrix—in Hazara has undergone a certain amount of metamorphism. The middle member of the series in Hazara is composed of purple shale and sandstone, the latter predominating. The limestone in Hazara attains a thickness of 2,000 feet, which, in the lowest layers, is sandy and of a deep purple colour, passing up into more purely calcareous beds of a lighter colour and even pink, cream-colour, or white. But the limestones are generally purplish or pink in colour, thus differing from the fossiliferous limestones of Chitral and resembling that of the Blaini area, which also is generally pink, though occasionally grey or blue. No fossils have been found in the Hazara limestone, but Middlemiss suggests that they may have been destroyed by metamorphism.

[1] GEOL. MAG., Dec. IV, Vol. IX, pp. 3–8, 49–58, January and February, 1902.

[2] Hazara is about 130 miles S.S.E. of Chitral. The rocks in both areas have a general foliation-strike of about N.E.–S.W.; so there is no means of correlating them, except by general lithological correspondence, until the intermediate ground is [illegible]veyed in detail.

[illegible] C. S. Middlemiss, "The Geology of Hazara and the Black Mountain": Mem. [illegible] Surv. Ind., vol. xxvi, p. 17 ff. (1896).

Thus, whilst the order of succession is the same in both areas, namely, conglomerate, sandstone series, and limestones, there are small differences, due possibly to a less thorough examination of Chitral, where the rocks were merely seen on a flying visit to a country very difficult of access. These differences consist mainly of differences of colour, which in Hazara is a prevalent purple through all three formations, whilst in Chitral only the sandstone is referred to as red. As such differences of colour are more probably due to secondary than primary causes, I think that their importance is not great when compared with the general similarities of the two series.

In referring to this case of Hazara I wish to point out that Mr. Middlemiss, after describing the infra-Trias in that area, and after having seen the well-known Blaini beds near Simla, had no hesitation in correlating the conglomerate of Hazara with the Blaini boulder bed. As it seems probable that the infra-Trias conglomerate of Hazara is the equivalent of the conglomerate below the Devonian limestone of Chitral, we have a further support for the correlation of the Chitral conglomerate with that of the Blaini beds, and therefore a further reason for regarding the Blaini conglomerate as at least Devonian in age.

There is, however, one element of doubt about the correlation of conglomerates in isolated areas, which must necessarily show certain points of correspondence, and that is illustrated by the fact that Mr. Middlemiss has also correlated the Hazara conglomerate with the boulder bed of the Salt Range, whose age, as shown by the associated fossils, is not greater than Upper Carboniferous. But at the same time he recognised certain differences, the chief being the absence of striated pebbles in Hazara, and it is in this important respect that the conglomerates of Hazara, Chitral, and Blaini all agree to differ from the boulder beds of the Salt Range and the Talchirs, whose age has been determined by fossil evidence.

In default, therefore, of evidence to the contrary we are justified in regarding the Chitral conglomerate as the horizon of reference for these similar conglomerates in the old unfossiliferous systems of the North-West Himalayas, whilst the boulder beds of the Salt Range, the Talchirs, and their foreign equivalents, which so often show direct evidence of ice-action, are younger in age.

III.—NEOLITHIC FLINT IMPLEMENTS FROM THE NORTHERN DESERT OF THE FAYÛM, EGYPT.

By H. J. L. BEADNELL, F.G.S., F.R.G.S., of the Geological Survey of Egypt.

(PLATES III AND IV.)

IN the course of my work in the deserts of the Fayûm during the last two years I found that over a certain area to the north of the eastern end of the Birket el Qurun lake flint implements, many of very fine workmanship, were of frequent occurrence. The accompanying Plates illustrate the common and most perfect types (reduced to about one-third).

For some years the existence of flint implements in the Fayûm has been known, as specimens of the more common forms had been collected by Beduin and sold to antiquity dealers in Cairo, in whose shops they were exposed for sale. Nothing, however, appears to have been known as to their exact locality and mode of occurrence, and, with the exception of one or two specimens figured by M. de Morgan, the types of this group have never been illustrated or described. The accompanying Sketch-map shows the particular part of the Fayûm desert whence these implements were obtained.

It is not intended to describe in detail the different specimens figured, or to attempt to divide them too closely into different classes; the chief varieties may be briefly referred to as follows:—

A. *Arrow and Spear Heads.* (Plate III, Figs. 1–9.)—These occur in a great variety of forms, the untanged sort being especially noticeable; the outer edge is frequently serrated. The finished specimens are usually of very fine workmanship. Probably they were largely used for spearing fish, as I shall show that these flint-using people lived on the borders of a great lake teeming with fish.

B. *Saw-edged Implements.*—The common varieties are seen in Plate III, Figs. 10–14.

C. *Cutting-edged Implements.*—In Plate III, Figs. 15 and 16, and Fig. 7 in Plate IV are spear-shaped forms, while Figs. 17–21 in Plate III and Figs. 1, 3–6 in Plate IV may be called knives, and were probably used for a variety of purposes. Fig. 2 is a curiously-shaped weapon.[1]

D. *Axe-like Tools.* (Plate IV, Figs. 8–11.)—The specimen shown in Fig. 8 is typically 'neolithic' in type, being beautifully ground and having a very true, sharp, cutting edge. The other three are also well-made tools, and show a combination of flaking and grinding. In addition to the above more or less definitely marked types, are numerous more rudely-shaped flints, many probably unfinished discarded failures, which do not lend themselves to classification. In one or two places the number of flakes lying together suggested that the work of fabrication had been done on the spot, but no extensive workings have as yet been noticed. Several varieties of flint and chert are noticeable, and although some of the material may have been supplied by the neighbourhood, it was probably mostly derived from the Lower Eocene limestones to the south or from the Cretaceous limestones of Abu Roash to the north.

With regard to the age of these flints, Mr. Quibell informs me that it is impossible to date them by comparison with known flints from tombs, etc. There may be certain resemblances between some of them and others of known age, but the group as a whole seems quite distinct. A most interesting and important fact, however, is their connection with the ancient topography of the Fayûm. Although I have traversed the Fayûm depression in almost every direction, I have so far failed to find any of these implements except

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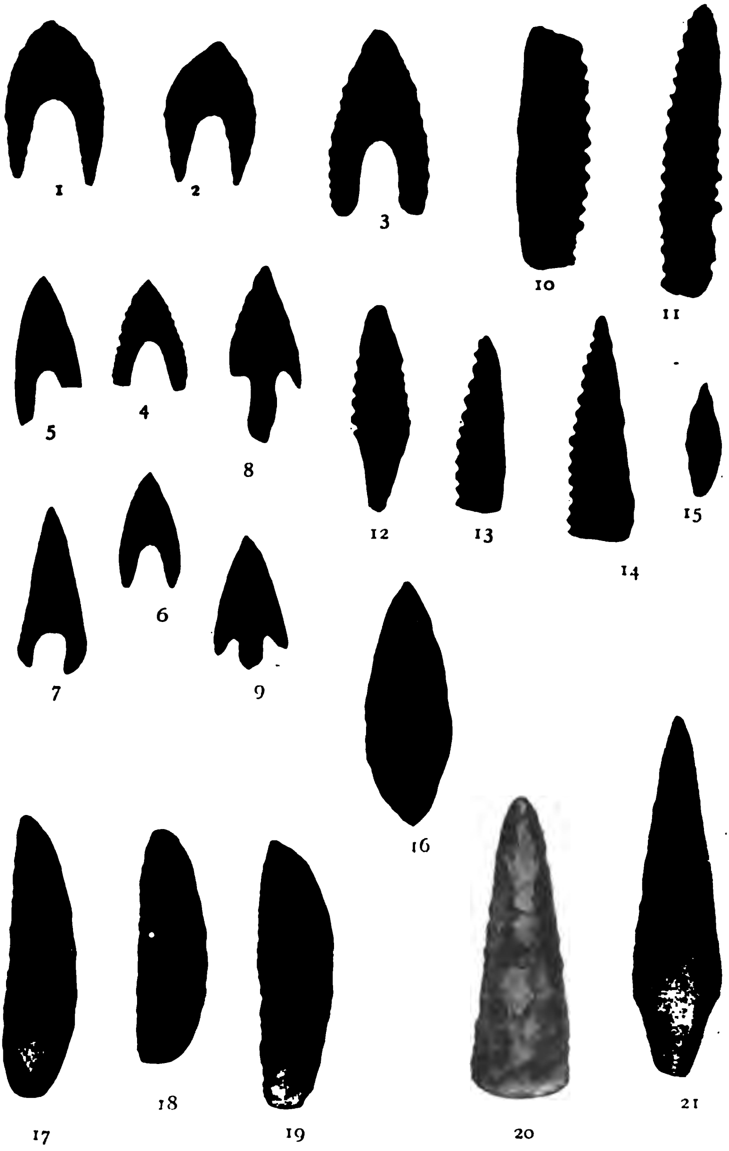
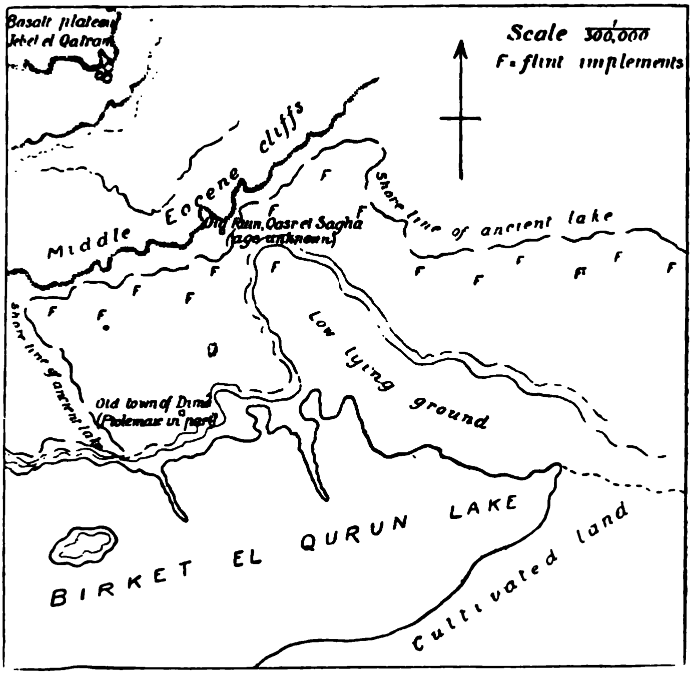
[[1] Perhaps a spearhead?—EDIT.]



Flint Implements from the Fayûm, Egypt.
About one-third nat. size.

in the comparatively restricted area in the north part. This part of the desert is covered with deposits indubitably laid down on the floor of a great lake—lacustrine sands, clays and marls full of the remains of fresh-water shells, fish, hippopotami, sheep, etc. The limits of the former lake are clearly defined, and the flint implements are almost wholly restricted to this area. They are very rarely found in the surrounding desert, and are most common along the outer fringe of the ancient lake. Nearly all the figured specimens were picked up on the surface of these lacustrine deposits, which are very soft, and are being rapidly cut up by wind-borne sand. The implements in nearly all cases show no signs of staining or patination, the upper and under sides being almost indistinguishable; they are quite fresh and unworn, and little polished by sand, exhibiting in fact no evidence of having been long exposed. I think there is no doubt that they have weathered out of the deposits themselves, although they have never as yet been actually discovered *in situ*. The people who used these flints certainly lived on the borders of this lake, which teemed with fish, hippo, and crocodiles.



Map of the northern part of the Fayûm, where the flint implements were found.

The presence of these deposits is alone sufficient to show the former existence of a great lake covering the floor of the Fayûm depression. It is quite certain also that the water of the lake was derived from the high floods of the Nile in the adjoining valley, and that the water obtained access to the depression through the low gap in the divide at Lahun. At what date the Nile water first entered the Fayûm is the crucial question, as the area must have been quite uninhabitable anterior to that event. It is, however, well known that prior to the Middle Empire a great lake existed, and was then brought under artificial control by Amenemhat I and his successors in the prosperous period of the Twelfth Dynasty (2200 B.C.). This Lake Moeris was used as a regulator of high and low Nile floods, and a certain amount of land was reclaimed from the central and highest portion of its bed; its level was between 23 and 24 metres above present sea-level, a height that agrees closely with that of the outer limit of the lacustrine deposits in the flint implement area.

The level of the lake was apparently kept at about the same level until after the time of Herodotus, about 1800 years later. If we could show that the old natural lake never reached the level of Lake Moeris in the Twelfth Dynasty, we should prove the flints to be of the same or later age. But it is probable that the old lake reached the same level soon after the first entrance of the Nile waters into the depression, which may have been, for anything I know to the contrary, thousands of years before. It must also be remembered that no flints resembling the present collection appear to have been discovered in the ancient towns and tombs of the Fayûm, so that our specimens are probably of earlier date than the most ancient monuments in the district.

The chief points on which evidence is wanted for dating these flints is as to when the Nile first gained access to the Fayûm depression, and as to the subsequent levels of the lake between that date and the Twelfth Dynasty. We must, however, regard them as Neolithic, both on account of their high perfection of workmanship and their connection with a lake which certainly existed far into the historic period of Egypt.

The evidence for Palæolithic man in Egypt appears to rest on very indefinite evidence. Throughout the country rudely worked flints may be picked up on the surface of the desert fringes, and those from the high plateaux have usually been designated 'palæoliths.' Whether any of these are in reality comparable with the 'palæoliths' of Europe is, I think, at present, an unanswerable question, but certainly in some cases their shape, workmanship, discolouration, and amount of weathering do not prove the contrary. Forbes,[1] who has recently described a large number of flints collected by Seton Karr in the Wadi el Sheikh of the Eastern desert, appears to be very much opposed to the Palæolithic view. He dates the Wadi el Sheikh implements as probably Twelfth Dynasty and later, and possibly going back to the Fourth; the evidence on which he relies appears to be the resemblance of some forms to flints discovered by Petrie in the old town of Kahun in the Fayûm. In the Wadi el Sheikh

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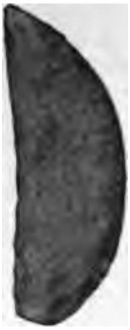
[1] H. O. Forbes, LL.D.: Bull. Liverpool Museums, vol. ii, Nos. 3 and 4 (January, 1900), pp. 77–115.

Geol. Mag., 1903. Decade IV., Vol. X., Pl. IV.



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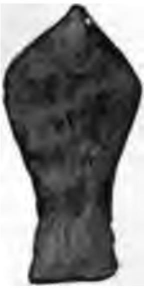

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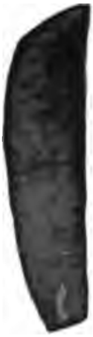

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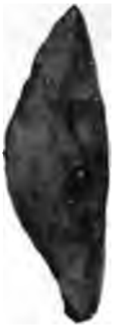

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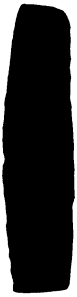

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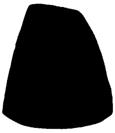

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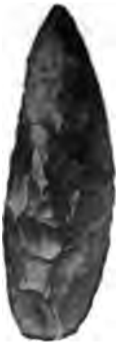

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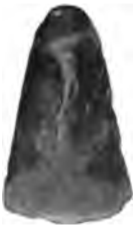

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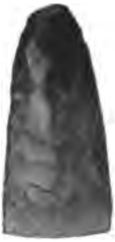

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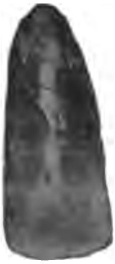

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Flint Implements from the Fayûm, Egypt.

About one-third nat. size.

the implements are found on the spot where they were worked, close to the pits from which the material was excavated. The edges of the flakes and the outlines of the flakings are "as sharp and unworn as the day they were made," that is to say, absolutely unweathered; I quite agree that a high antiquity cannot be assigned to these. But, according to the same authority, other and associated specimens are deeply eroded and rounded at the angles and edges. Dr. Forbes appears to have no doubt as to the two kinds, the worn and unworn, being of the same age, but personally I do not feel at all convinced of this, especially as no explanation is given as to why some flints have undergone so great a change while others remain absolutely fresh and unworn. The amount of weathering should be one of the most important criteria as to the length of time that an object has been exposed on the desert surface. It may be said that as all these flints were found near together around the old pits it is probable that they are all of the same age; but, if a superior quality of flint occurs in the Wadi el Sheikh, I do not see why it should not have been discovered and worked even in Palæolithic times, or why subsequent races should not have rediscovered and worked the same beds, and their products have mixed on the surface.

The fact that many of the so-called Palæolithic flints of the Theban plateau were found in close association with nodules and the flakes struck from them is, according to Forbes, conclusive evidence that they cannot be of any great age. He says, "it is impossible to believe that these could remain (even in a single instance) undisturbed from the Palæolithic days of Europe to the present time, when the forest under which they were made and the forest soil on which they reposed have been entirely carried away." But is it certain that the high plateau was then clothed with forests? What evidence is there to show that it differed in any important respect from its present aspect? And if, as I suggest, desert conditions obtained then as now, and man merely worked his flints along the edges of the plateaux overlooking the Nile Valley, I see no reason why flint implements, dating even from Palæolithic times, should not in favourable cases be still found in the spots where they were left, surrounded by the flakes struck off in manufacture. On the flat plateaux the occasional rains which fall can effect but little transport of material, and merely lower the general level by dissolving the underlying limestone, so that the plateau surface is left with a coating of nodules and blocks of insoluble flint and chert. Flint implements might thus be expected in many localities to remain for indefinite periods, but they would certainly become more or less 'patinated,' pitted on the surface, and rounded at the angles after long exposure to heat, cold, and blown sand. Flints that retain their original clearness and sharpness of angles cannot be of high antiquity, unless they have been protected by superficial deposits.

It must, I think, be admitted that most of the conclusions formed as to the age of flint implements in Egypt, other than those in tombs, are based on insufficient evidence, and on faulty assumptions of Egyptologists as to the geological and meteorological conditions in the Pleistocene and Recent periods. For instance, Mr. Griffith[1] writes:—"Egypt, as we know it, came into existence in the Pleistocene epoch, and then began the alluvial deposit to which the richness of the soil is due. But before the formation of the Nile Valley Palæolithic man was on the ground." Again, Petrie[2] writes:—"The valley of the Nile is cut down a depth of 1,400 feet through a limestone plateau, the edges of which are deeply channelled with drainage valleys. . . . On the top of the 1,400 feet plateau are great numbers of worked flints of Palæolithic type. . . . That the high plateau was the home of man in Palæolithic times is shown by the worked flints lying scattered around the centres where they were actually worked. The Nile, being far higher then, left no mud flats as at present for habitation, and the rainfall, as shown by the valley erosion and waterfalls, must have caused an abundant vegetation on the plateau where man would live and hunt his game."

What evidence is there that Palæolithic man was on the ground before the formation of the Nile Valley? In all probability the valley came into existence even long before the earliest times of European Palæolithic man. Again, the presence "of worked flints lying scattered around the centres where they were actually worked" does not necessarily prove that the plateau was inhabited by man. If early man could obtain better material there than elsewhere, as was probably the case, he would naturally have manufactured his implements there. Most or all these implements are found near the edge of the plateau at no great distance from the valley, and even under the present rigorous desert conditions I have frequently found Fellahin from the valley up to thirty and forty miles inland, remaining for days away from the habitable cultivation working small veins of rock-salt or gathering bats' dung in caves. In exactly the same way may early man have gone into the desert fringe to obtain and work his flint. Again, do the "valley erosion and waterfalls" prove a greater rainfall in the time of man? It seems to me that the greater part of the wadis may very well have been carved out before man appeared on the scene; while it is doubtful if there was ever much erosion of the valley by the Nile, the main part of the gorge probably having been formed in Pliocene times largely by earth-movements. If the plateau was really vegetated and habitable, how is it that no traces of man are found at any distance from the Nile Valley? I have crossed the Libyan desert and traversed a good deal of the Eastern plateau, but never met with any remains of early man or anything to suggest that either plateau might have been habitable even in very remote periods.

I do not pronounce either for or against Palæolithic man in Egypt, but I do say that so far both evidence for and against has been unsound. We must carefully collect and examine all available facts both archæological and geological, as only by a combination of both can the question of the age of different groups of flints and the presence or absence of Palæolithic man be determined.

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[1] Archæological Report of the Egypt Exploration Fund, 1896–7, p. 48.

[2] Petrie & Quibell: "Naqada and Ballas," p. 49.

IV.—On the Constitution, Origin and Dehydration of Laterite.

By T. H. Holland, A.R.C.S., F.G.S., Geological Survey of India.

I. Introduction.

A DESCRIPTION by Professor Max Bauer[1] of rock-specimens collected in the Seychelle Islands includes a special discussion of the laterite, which, he shows, agrees in essential characters with bauxite. As bauxite is the most valuable source of aluminium, and its origin has hitherto been without a completely satisfactory explanation, this work by Bauer opens a question of double interest to the owners of land in the humid parts of the tropics.

As with many such interesting questions, more than one worker has blundered near the correct solution without feeling his convictions sufficiently mature for publication.[2]

Apart from priority secured by publication, I shall not be departing far from justice to others in giving Dr. H. Warth, then of the Geological Survey of India, the credit of having first, or at any rate independently, suspected laterite and bauxite to be essentially similar. In 1893 Dr. Warth found a specimen in the Palni Hills, Madras Presidency, which so strongly reminded him of bauxite that he had an analysis made, and this showed over 60 per cent. of alumina (Al_2O_3). The analysis did not, however, show the constitution of the laterite, and did not distinguish between the alumina combined with silica and that present as a simple hydrate. For various reasons, constituting a story in itself, this question had to give place to others, and was merely noted by Dr. Warth and myself as one to be kept in mind.

During the four years following, my observations in Peninsular India gradually led me to suspect that kaolin and many other hydrated minerals, generally regarded as weathering products, have not originated by the action of subaerial agents, but some, if not all, of them are produced by vapours from subterranean sources, whilst, on account of its peculiar distribution, serpentine must remain under the suspicion of being due to submarine action until its mode of occurrence in India can be explained on other grounds.[3] Kaolin has, of course, been frequently referred to as a product of solfataric action, and the evidences have recently received exhaustive treatment by H. Rösler, who, without referring to Bauer's work, doubts Glinka's suggestion that kaolin and laterite are mere climatic facies of weathering products.[1]

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[1] Bauer, "Beiträge zur Geologie der Seychellen": Neues Jahrb. für Min., etc., 1898, vol. ii, p. 163.

[2] Cf. Henatsch, "Ueber Bauxite und ihre Verarbeitung": Inaug. Dissertation, Breslau, 1879. Mr. F. R. Mallet, to whom I am indebted for reading the proofs of this note during my absence from England, approached dangerously near comparing laterite with bauxite when he pointed out in 1881 that the ferruginous beds of Ulster, associated with bauxite, resembled the laterite on the Deccan Trap in India. ("On the ferruginous beds associated with basaltic rocks of North-Eastern Ulster, in relation to Indian laterite": Rec. Geol. Surv. Ind., vol. xiv, p. 139.)

[3] Holland, "A Contribution to the Discussion on Rock-Weathering and Serpentinization": Geol. Mag., 1899, Dec. IV, Vol. VI, p. 540.

The frequent occurrence of kaolin as an undoubted product of what Judd defined as solfataric action,[2] and the absence of evidence to show that it was formed by the action of subaerial agents, naturally suggested that our laterites, generally spoken of as ferruginous clays, should be more critically examined. Dr. Warth's suggestion naturally occurred to me, and steps were taken to investigate the chemical constitution of laterite; but before any real progress in the work had been made, Dr. Bauer's paper appeared, and, as I think, practically settled the question. What is true of the Seychelle laterite must, so far as one can judge, be true also of the laterites in India which have not been sifted by running water. To this point and a speculation I will return after briefly summarizing Bauer's results.

The following two analyses by Professor Busz are employed in Bauer's discussion :—

	I.	II.
SiO_2	52·06	3·88
Al_2O_3	29·49	49·89
Fe_2O_3	4·64	20·11
CaO	trace	—
H_2O	14·40	25·98
	100·59	99·86

No. I is a laterite capping granite, whilst No. II was found on, and was presumably derived from, diorite on the Seychelle Islands. Bauer says that the treatment of the first specimen with boiling hydrochloric acid leaves about 50 per cent. of fine quartz-sand, which can also be detected when the laterite is moulded between the fingers. Similar treatment of No. II leaves a correspondingly small residue of quartz. He, therefore, assumes that the silica is present as quartz mechanically mixed with the other constituents; thus, by removing the silica, and calculating the results to 100, we obtain :—

	I.		II.	
	Per cent.	Mol. ratio.	Per cent.	Mol. ratio.
Al_2O_3	60·68	0·36	51·98	0·34
Fe_2O_3	9·56	0·04	20·95	0·10
H_2O	29·76	1·00	27·07	1·00
	100·00		100·00	

In both of these cases the molecular ratio of $Al_2O_3 : H_2O$ approaches that of gibbsite, $Al_2O_3 . 3\,H_2O$; but even without considering the water united with the ferric oxide it is still deficient, showing that with the gibbsite there is a certain amount of a lower hydrate, probably diaspore, $Al_2O_3 . H_2O$.

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[1] Rösler, "Beiträge zur Kenntniss einiger Kaolinlagerstätten": Neues Jahrb. für Min., 1902, vol. xv, Beilage-Band, pp. 231–393.

[2] Judd, Quart. Journ. Geol. Soc., 1890, vol. xlvi, pp. 341–382.

Microscopic examination shows that the ferric hydrate occurs as a casual staining between the fine scales of gibbsite, the two being mechanically mixed; and as the iron-staining varies in colour from yellow, through brown to dark red, the hydrate varies in composition, including in different specimens, or at different stages of dehydration in the same specimen, the various imperfectly defined forms of ferric hydrate which have been given specific names—limnite, $Fe_2O_3 . 3H_2O$; xanthosiderite, $Fe_2O_3 . 2H_2O$; limonite, $2Fe_2O_3 . 3H_2O$; göthite, $Fe_2O_3 . H_2O$; and turgite, $2Fe_2O_3 . H_2O$.

The results obtained by the analysis of a 'laterite sand'—the so-called 'low-level' or detrital laterite of Indian geologists—show a still smaller proportion of water, indicating a larger proportion of diaspore and probably of the less hydrated forms of ferric oxide. In this case, also, there is an admixture of quartz-grains, some, as they ought to be, partly rounded.

Now then, there appears to be no doubt that during the weathering of aluminous silicates in the tropics, the silica, alkalies, and alkaline earths are removed in solution, whilst the alumina and ferric oxide become hydrated and remain behind mechanically mixed, often as pseudomorphs of the original mineral structures of the rock. In microscopic structure and in chemical constitution Professor Bauer has now shown that laterite reproduces the essential characters of bauxite. As laterite is so abundant in tropical, moist climates, its occurrence offers a simple explanation for the origin of bauxite, and is merely another expression of the results of the prevalence of tropical conditions in some higher latitudes during past geological ages. With fair proof of the fact that the aluminous base of laterite is a hydrate and not a hydrous silicate, several questions naturally present themselves: to call attention to some of these is the object of this paper.

II. POSSIBLE ORGANIC ORIGIN OF LATERITE.

The Seychelle specimens do not tell the whole story; for there are laterites *and* laterites. In India we distinguish between 'high-level' and 'low-level' laterites: the former are lying on the rock-masses from which they have been formed without removal from the place of origin. Amongst these we have lateritic caps below elevations of about 5,000 feet in the Peninsula of India, with marked concretionary structures, whilst at higher levels the decomposition-products show less pronounced signs of concretionary structures, and often retain perfect casts of the original structures of the rock from which they have been derived. 'Low-level' laterites have a detrital origin, and consist of sand-grains in which quartz as usual predominates; they merely differ from other detrital rocks in the abundance of lateritic cement. In this form, which is our most abundant type, and the one consequently most taken in the regretfully few analyses which have been made, there is a much smaller quantity of alumina and a higher percentage of iron. This is due probably to mechanical sorting by running water, the light, scaly gibbsite being carried away, whilst the heavier ferric hydrate remains with the grains of sand. Thus, taught by the natives who sometimes use it as an iron-ore, we have been blinded to the true nature of laterite by keeping an eye on its possible use as a source of iron. That the Seychelle specimens are of the 'high-level' type seems probable from the fact that the ratio between alumina and ferric oxide in each case corresponds approximately with that of the rocks on which they lie, granite in one case and diorite in another. They retain, too, just as much silica as one would naturally expect to occur as free quartz in the original rocks.

With laterite one ought also to consider the material known generally as *kunkar*, without much respect to the original meaning of the Hindustani word. Laterite and *kunkar* appear to be formed by precisely the same process; but they differ from one another in composition, and the reason for this is seen in South-West India. The Western Ghâts of Malabar divide areas which differ greatly in rainfall. The south-west monsoon, breaking against the hills of Travancore and Malabar, precipitates between 100 and 200 inches of rain on the western slopes during the wet season; whilst on the eastern side the plains of Coimbatore receive no more than about 20 inches of rain during the year, and the field-worker in Coimbatore sees with satisfaction the great bank of cloud spending its fury on the Ghât ranges, whilst a cool breeze blows through the Palghât gap, and spreads itself over the eastern plains with seldom more than a sprinkling of rain. As we pass from the west to the east side of the western ridge, there is a complete change in the weathering products. On the western side, where running water is abundant, there is the crust of typical ferruginous laterite. On the east side, where the climate is quite as moist, but actual precipitation of water very limited, the ferruginous character is masked by the great predominance of lime-carbonate, and the material, from its resemblance in composition to the nodular bodies in the Gangetic alluvium, is known to the Public Works officer as *kunkar*, being similarly used as a source of hydraulic cement. In *kunkar* we have the *total* products of decomposition; exposure of this to running water would remove the lime, and leave a residue indistinguishable from laterite. Both substances thus originate in the same way by the decomposition of rocks in a tropical, moist climate.

Laterite is characteristic of the tropical belt, and so, too, is *kunkar*; but this possibly is merely a case of intensity: both may be formed to a less noticeable degree in temperate regions. Still, in their typical forms these peculiar substances are eminently characteristic of the tropics — one of a wet and the other of a humid climate.

That the formation of laterite is a mere question of average temperature seems unlikely, for lateritization is very prominent at elevations of 6,000–7,000 feet in the Nilgiri and Palni Hills in South India, where the temperature varies very little above or below 60° F. The concretionary structure so characteristic of the laterite of lower levels is not, however, developed at this elevation, which accounts for the restrictive remark in the Manual of the Geology of India[1]; and it is likely that the high temperature assists the concretionary structure in the way indicated in the sequel. Preparatory to the suggestion offered below it should be premised that the climate of the Nilgiri and Palni highlands differs from that of the temperate zone in the absence of a real winter: in the fact that very low temperatures do not occur; so a winter temperature, maintained for a long period, may be fatal to pronounced lateritic development, and may possibly prevent its formation altogether in high latitudes, where, as we know, fresh felspars are preserved in detrital materials.

On the other hand, when vapours (or liquids) from deep-seated sources act on aluminous silicates, presumably at high temperatures, hydrous silicate of alumina, kaolin, is formed, and not, so far as recorded, the simple hydrous oxides.

Now, putting these facts together, I would suggest that we look for the explanation of laterite, not in simple chemical reactions, but in the action of some lowly organism having the power of separating the alumina, which, after the manner of many plants, it does not want, from the silica, which is necessary for its life, but which, being in a soluble form, is removed again by the alkaline solutions. Such a form of life might thrive in the moist climate of the tropics, even to a temperate altitude, but might find life intolerable in a land subject to severe winters, such as we get in the temperate zone and in North India, where we find no laterite. Such an organism would form *kunkar* as well as laterite in a moist, warm climate, the difference in the products being due merely to their after-treatment by water. For obvious reasons, too, such an organism could not live under conditions of kaolinization. But apart from the agency of life I see no chemical reason why an aluminous silicate should undergo a more complete decomposition at the comparatively low temperature of the tropics than at the high temperature of subterranean situations; the contrary, indeed, seems more natural. And if the temperature *does* so affect chemical action, we still might wonder why laterite does not occur on the foot-hills of the Himalayas, where there is an abundance of moisture and where the average annual temperature is as high as on the Nilgiris. Chemical changes which cease at low temperatures commence again as soon as the suitable physical conditions are restored, and laterite, consequently, would be expected to form in North India during the summer. But the distribution of an organism might very well be limited by the extremes of climate, when possibly the average annual temperature is not below what would be congenial to it if maintained.

If this fancy turns out to be well founded we must add lateritization to the long list of tropical diseases, against which even the very rocks are not safe. But it is a big step between the establishment of a reasonable suspicion and the actual detection of the bacillus at work. There may be many forms of life taking advantage of the soft, moist, lateritic medium, but it will not be an easy matter to convict, amongst these, such as may take an active part in breaking up the aluminous silicates.

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[1] 2nd ed., 1893, p. 375.

It is hard to believe that the few degrees by which a tropical exceeds a temperate climate is sufficient to so strikingly increase the chemical activity of the weak organic acids percolating through the soil. But that such a small difference of temperature affects low forms of life is painfully evident to those who have to maintain the daily fight of life in the tropics. The enormous depths to which the complete destruction of rocks extends in moist, tropical, climates has frequently been described by travellers; but no description reproduces the actual impression caused by the deep cuttings in places like the hill-roads of South India, where, on a newly-cut face the minute structures of the gneisses are perfectly preserved in material as soft as putty. And yet, as I have pointed out elsewhere,[1] there is a sharp and sudden passage from the soft decomposition-product to a rock so fresh that not a sign of alteration can be detected in it under the microscope. This is true, too, of boulders isolated from the main mass of rock and embedded in the decomposition-product: within the distance of an inch one passes from the soft material, which we have unwittingly called clay, to ideally fresh, water-clear felspars.

If this alteration were due to the mere infiltration of water through the rocks one would expect to find signs of incipient alteration to greater depths in the solid rock. But if it is due, as I suspect, to a growth at the surface, the sharp line of junction is no more than we should expect. Darwin, against whose observation nothing was secure, and who never observed without deduction, thought the thick decomposition mantle on the Brazilian coast was due to hydration under submarine conditions.[2] But *that*, we are certain, is not the case with the South Indian hill-ranges; the action is purely subaerial, and the sea has never been near the rocks.

But the existence of low forms of life capable of decomposing aluminous silicates would be no surprising discovery after what we know of the action of the so-called nitrifying bacteria in converting inorganic salts into proteids for the use of higher plants; of those which, contrariwise, break up nitrogenous organic matter to form nitrates; of the peculiar anaërobic forms which break up sulphates and separate the sulphur, and of the aërobic forms which convert sulphides into sulphates.

Amongst the forms almost certain to occur in newly-forming laterite will be relatives of the remarkable genera *Crenothrix*, *Cladothrix*, etc., which are active agents in the oxidation of ferrous salts, depositing the insoluble form of ferric oxide in their cell-walls as a part, apparently, of the physiological activity of the organism. There are probably bacteria akin to these which assist in the oxidation of the ferrous salts released during the lateritization of basalt. But the important forms to identify will be those which supply the necessary energy for the more complete disintegration of an aluminous silicate than appears to be possible by chemical means alone at the temperature of the atmosphere. Our explanation cannot be accepted as wholly satisfactory until the agents have actually been identified; but there is enough circumstantial evidence to warrant the suspicion that a special form of organism is the direct cause of lateritization in the tropics.

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[1] Holland, "The Charnockite Series": Mem. Geol. Surv. Ind., 1900, vol. xxviii, p. 197.

[2] Voyage of the "Beagle," 2nd ed., 1876, p. 427.

III. THE DEHYDRATION OF LATERITE.

There is another interesting question suggested by laterite. The analysis by Professor Busz of the lateritic sand from the Seychelles shows a lower degree of hydration than that which characterizes the laterite formed *in sitû* on the granite and diorite. This agrees exactly with our experience in India.[1] 'Low-level,' recemented laterite is always less hydrous than the 'high-level,' freshly-formed material; and there is in general a correspondence between the development of concretionary structures and the degree of dehydration. Soft, yellow masses, freshly cut out with a spade, gradually become hard and deepen in colour, until they approach a reddish-brown. Every Public Works officer knows this, and feels with satisfaction that his bridges, built with laterite, strengthen with age.

The drying of laterite is not a case of mere loss of mechanically included water: the ferric hydrate parts with combined water and passes from the condition of limonite, with its yellow colour in powder, to that of turgite, whilst at the same time a concretionary, and in places microcrystalline, structure is developed. The hydrated alumina apparently undergoes a similar change, passing from gibbsite, $Al_2O_3 . 3H_2O$, to diaspore, $Al_2O_3 . H_2O$, and this irregular loss of water is probably the cause of variation in bauxite, which is intermediate between gibbsite and diaspore, but is inconstant in composition, as one would expect in a mixture.

Our knowledge of the constitution of ferric hydrates is very imperfect, and, of the natural forms, far less precise than one would imagine from the number of specific names employed to distinguish forms which are probably mere mixtures possessing insufficient individuality to crystallize. Göthite, corresponding to diaspore, is the only hydrate definitely crystallized. But the anhydrous oxide, hematite, on the other hand, shows an eminent tendency to crystallize, and is amongst those minerals which might be well spoken of as crystallographically robust. The tendency to crystallize is thus exhibited by the anhydrous and least hydrated members of this group.

At the risk of sacrificing precision for brevity we can refer to this tendency for the physical molecules to come together and form crystals as stronger than the chemical affinity between ferric oxide and water. The two manifestations of energy thus come into competition, and the loosely held second and third molecules of water are ejected to permit the crystallization of göthite, $Fe_2O_3 . H_2O$, or possibly even the whole of the water to form hematite, Fe_2O_3. It must be this action which develops the crust of turgite on nodular masses of limonite; for turgite itself has no individuality and is probably only an intimate mixture of anhydrous and hydrous oxides.

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[1] GEOL. MAG., December, 1899, p. 542, note 1.

In one sense the change from gibbsite to diaspore is analogous to the dehydration of ferric hydrate. A comparison of the molecular volumes of corundum, Al_2O_3; diaspore, $Al_2O_3 . H_2O$; and gibbsite, $Al_2O_3 . 3H_2O$, indicates a lower molecular volume for one molecule of water in diaspore than for each of the three molecules in gibbsite. The figures are as follows:—

$(v)\ Al_2O_3 . H_2O - (v)\ Al_2O_3 = 35{\cdot}0 - 25{\cdot}5 = 9{\cdot}5$ . . . . (*a*)
$(v)\ Al_2O_3 . 3H_2O - (v)\ Al_2O_3 . H_2O = 66{\cdot}5 - 35{\cdot}0 = 31{\cdot}5$. (*b*)
$(v)\ Al_2O_3 . 3H_2O - (v)\ Al_2O_3 = 66{\cdot}5 - 25{\cdot}5 = 41{\cdot}0$ . . . (*c*)

Of these three equations, (*a*) shows the volume of one molecule of water in diaspore to be 9·5, which is identical with the result obtained by deducting (*b*) from (*c*), whilst (*b*) gives the volume of the second and third molecules of water in gibbsite to be together 31·5, or an average of 15·75.[1] Thus, the constitution of gibbsite is more correctly expressed by the formula $Al_2O_3 . H_2O + 2H_2O$. Now, the relation between the first molecule and the other two is precisely analogous to the relation between Graham's 'water of halhydration' and the 'water of crystallization' in soluble salts. Thorpe and Watts have shown—with sulphates as examples—that the first molecule has a volume near 10, whilst the water of crystallization may be as much as 16. They have also confirmed the conclusions of Graham, and extended by Favre and Valson, to the effect that more heat is evolved in the act of combination of the first molecule—that in which the greatest contraction occurs—than is evolved in the combination of the remaining molecules. Similarly, the water of crystallization is driven off more easily than the water of constitution or halhydration.[2]

The evidence of the molecular volumes thus indicates a willingness on the part of gibbsite to rid itself, on small provocation, of two molecules of water. This willingness is shown by its ready transformation into diaspore. In the case of limonite the tendency to dehydration is still more pronounced; for it seems from the evidence of laterite, that even a completely anhydrous condition can be attained in a tropical climate which is at the same time humid for much of the year. Whether limonite represents a chemical compound or not it is impossible to say, but gibbsite, which forms distinct crystals, is presumably a definite compound, and its loss of water must consequently be a chemical change of the endothermic kind. But where, seeing the compound is not heated from extraneous sources, does the energy come from? I believe the answer to this question is given by the fact that the dehydration is accompanied by the crystallization of the molecule of ferric oxide and of the aluminic hydrate with the lowest possible molecular volumes.

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[1] The actual identity of results by these two equations is, of course, accidental; for it is not known that the molecular volume of Al_2O_3 remains constant in all its combinations. But, for reasons that need not be stated now, it is certain that its variations in crystallized compounds is very much less than the difference between the molecules of water.

[2] Thorpe & Watts, "On the Specific Volume of Water of Crystallization": Journ. Chem. Soc., 1880, vol. xxxvii, p. 102.

The concretionary structures which characterize laterite and bauxite are but the foreshadowings of crystallization—a preliminary segregation of the molecules, accompanied by expression of the water—to which all well-defined chemical compounds aspire, though molecular movement may not always be sufficiently free to produce noticeable results at ordinary temperatures.

The comparative opacity of the iron-oxides prevents the use of the microscope as a means of tracing the passage from the most hydrated to the anhydrous condition; but it seems very likely, judging by the analogy of the aluminous hydrates, that some of the intermediate stages are mere mixtures, and that there is the usual tendency to pass into the forms with smaller molecular volumes. The tendency to crystallize—the grouping of physical molecules—is analogous to the manifestation of chemical affinity amongst chemical molecules, and there must, in the same way, be differences of intensity. I am indebted to Professor A. H. Church for references to the case of arsenious oxide, As_4O_6, which, on passing from the amorphous to the octahedral form, gives out 5,300 gram-units of heat, whilst the passage from the amorphous to the monoclinic form is attended by the production of 24,950 heat-units per As_4O_6 grams. In these cases the octahedral form has a lower molecular volume than the amorphous, and the monoclinic form lower than either. Thus, the change of physical state amongst solids may result in a change of entropy as great as that due to chemical change; that, in fact, crystallization may cause a measurable dissipation of energy.

Thomsen gives the heat of formation of aluminic hydrate $[Al^2, O^3, 3\,H^2O]$ as 388,920 calories, and of ferric hydrate $[Fe^2, O^3, 3\,H^2O]$ as 191,150 calories, both values being less than the heat of formation of the respective anhydrous oxides.[1] Without a direct determination it would be unsafe to regard the dehydration of these compounds as an exothermic change; but with the simultaneous crystallization of diaspore in one case and of göthite or even hematite in the other, one is safe in assuming that the changes manifested by the development of concretionary structures in laterite are in the total exothermic, and that the 'tendency' to crystallize is a condition worthy of serious consideration and of comparison with chemical changes.

The expression *crystalline affinity* might be employed conveniently as an analogue of chemical affinity for the tendency exhibited by substances to form crystals by the regular disposition, as we imagine, of physical molecules. That this tendency is variable is evident from the fact that some substances readily form well-developed crystals, whilst others require a prolongation of the physical conditions which are favourable. The display of energy due to chemical union is in general sufficiently pronounced to be noticeable; but there must also be a display of energy when physical molecules have the privilege of exhibiting crystalline affinity, and it is not unlikely that in some cases the heat of formation of a crystal may be greater than that of a chemical compound, in which case, as the hydrates of iron and alumina appear to teach, a chemical compound may be broken up to permit some constituent to crystallize. We shall probably be near the truth if we regard the crystalline affinity as the heat of formation of a double molecule. Thus the thermal value of $[Fe^2O^3, Fe^2O^3]$ may exceed $[Fe^2O^3, 3\,H^2O]$, in which case, under suitable physical conditions, the water would be driven out of limonite and a crystal of hematite formed, because the system is one containing potential energy due to the proximity of molecules of Fe_2O_3. Similarly, the potential energy of a system in which $Al_2O_3 . 3\,H_2O$ exists contains sufficient potential energy to displace the two molecules of water having a high specific volume to form a crystal of the compound $Al_2O_3 . H_2O$. In other words, the thermal value of $[Al\,H\,O^2, Al\,H\,O^2]$ is greater than $[Al\,H\,O^2, H^2O]$, and the formation of diaspore at the expense of gibbsite is an exothermic change capable of spontaneous development under suitable conditions.

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[1] J. Thomsen: "Thermochemische Untersuchungen," 1882, vol. iii, pp. 240, 294. Roberts-Austen: *Nature*, August 8th, 1901, p. 360. Naumann: "Thermochimie," 1882, p. 514.

At a high temperature diaspore would change further to corundum, a change equivalent to the formation of hematite at lower, probably at ordinary, temperatures. Aluminic oxide thus shows a greater affinity for water than ferric oxide does, which is shown by the facts, (1) that limonite is not found crystallized, whilst gibbsite forms definite crystals, and (2) that gibbsite at ordinary temperatures is reduced to diaspore as an exothermic change, whilst the anhydrous compound, hematite, is formed from ferric hydrate under similar circumstances.

One is aware, of course, that we have but a vague idea of what the amorphous state means. But the passage to the crystalline condition is in general one accompanied by a decrease in molecular volume; and with the striking case of arsenious oxide before us, it would be well to examine more critically cases in which the manifestation of energy is less pronounced, though necessarily existent and possibly measurable.

IV. SUMMARY.

The objects of this note are three: (1) to call attention to the essential chemical similarity between laterite and bauxite; (2) to offer a theory for the formation of laterite in the moist tropics; (3) to suggest an explanation for its spontaneous dehydration.

(1) Laterite has generally been referred to as a ferruginous clay; but if the term clay is restricted to substances having a basis of hydrous silicate of alumina, this definition is incorrect. The

alumina in laterite exists, as it does in bauxite, in the form of hydrous oxides. Kaolin must thus be removed finally from the list of weathering products; it is formed generally, perhaps exclusively, by the action of subterranean vapours on aluminous silicates. This conclusion necessitates a re-examination of many so-called argillaceous substances; many doubtless include the kaolin already existing in the kaolinized aluminous silicates before they are exposed to the weather. But it is probable that some of the red clays of past geological ages, formed under subaerial conditions, contain free hydrous oxides of alumina; and for those that are shown to contain hydrous silicate of alumina, it would be well to test the possibility of a secondary reunion of aluminic hydrate and free silicic acid.

(2) To account for the fact that an aluminous silicate undergoes a more complete disintegration under tropical conditions than under the deep-seated and presumably high-temperature conditions of kaolinization, the writer suggests that laterite is due to the agency of lowly organisms, possibly akin to the so-called nitrifying bacteria. With these there are probably forms akin to the bacteria which oxidize and fix ferrous compounds, and which, precipitating the silica in the colloid form, permit its removal by the dilute alkaline solutions simultaneously formed. This would account for the facts, (*a*) that laterite is confined to the tropics, or at least is more conspicuously developed under tropical conditions; (*b*) that although the laterite cover is 100 feet or more in thickness, there is a sharp change from the soft decomposition-product to the absolutely fresh rock below; (*c*) that though laterite can form at temperate altitudes, it is not observed in temperate latitudes, where, with a similar average annual temperature, there is a prolonged winter; and (*d*) that laterite is a superficial product.

(3) The development of concretionary structures in laterite being accompanied by the loss of water, it is suggested that, in compounds where a constituent is loosely held, the 'crystalline affinity' by which physical molecules tend to unite and form crystals may be more energetic than the chemical affinity; that, in other words, the heat of formation of a crystal of $Fe_2 O_3$ may be greater than the thermal value of the compound $[Fe^2 O^3, 3 H^2 O]$. Hence crystalline hematite may form spontaneously at the expense of amorphous limonite. Similarly, the two molecules of water having a high specific volume in gibbsite ($Al_2 H_2 O_4 . 2 H_2 O$) are expelled by the formation of a crystal of diaspore ($Al_2 H_2 O_4$). Assuming that the change of entropy can be expressed in thermal formulæ, the value $[Al H O^2, Al H O^2]$ must be regarded as greater than $[Al H O^2, H^3 O]$, and both limonite and gibbsite must be regarded as unstable at tropical temperatures when both exist together. As the ferric hydrate shows a greater tendency towards dehydration than the corresponding hydrate of alumina, it possibly acts as a catalytic agent; and it would be unsafe, therefore, to assume, from the evidence of laterite, that *pure* gibbsite possesses the power of spontaneous dehydration.

V.—The Permanence of River Valleys.

By the Rev. E. Hill, F.G.S.

A GOOD deal has been written on the permanence of ocean basins, but about the permanence of river valleys I have never noticed any discussion. The causes which tend to maintain the existence of a river valley are indeed obvious and simple; probably this simplicity and obviousness are the very reasons why so little has been said. Yet even if superfluous it may be interesting to bring together some of these causes, such at least as have come into my mind.

What actions can even temporarily obliterate a channel cut into the surface of the land? Submergence followed by re-elevation: what will that effect? During submergence sediment may be deposited. If this be deposited as a mantle of equal thickness over the whole bottom, the surface on re-elevation would have the same shape as before; hills and valleys would reappear of equal relative heights and depths. Probably, however, the amount of sediment would be greater in greater depths: more would be deposited in valleys than over hills. Then on re-elevation the surface would appear with features smoothed down, but not obliterated. Where a valley had been, a valley would again be; less deep, but with a fall in the same direction, tributaries in the same position, and the same catchment basin as before. Rain and rivers would resume their old courses and their old work; the valleys would be the same as before. Imagine even the most improbable case of a sedimentation such as should bury hills and valleys alike; let every feature vanish as a path is hidden beneath a sheet of snow; even then the valley would reassert itself. For the sediment would be moist, and on re-elevation would dry and shrink. Shrinkage would be most where depth was greatest: that would be where the valley had been. Thus shrinkage would restore the outlines of the old drainage system; water would follow the same courses as before; each valley would reappear and its excavation begin anew.

If obliteration be effected subaerially there arises a different state of things. Messrs. Anderson and Flett describe[1] the Souffriere eruptions of 1902 in St. Vincent as having with their ashes filled up the stream valleys level with their banks: "those who visited the country shortly after the first eruption describe it as having a smooth, gently rolling surface like that of blown sand." Blown sand itself or steppe dust may obliterate channels. One may imagine a complicated river system thus replaced by an almost featureless surface of æolian loess. Yet even in this case the original relief of the ground will surely seldom fail to influence its subsequent shape. In the paper cited above it is said[2] that after rain had fallen "the knife-edges between the valleys were the only parts retaining the original smooth surface . . . already many of the streams have thoroughly cleaned out the ash from the upper part of their channels . . . the valleys at first almost obliterated are now reassuming their old appearance."

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[1] Royal Society Proceedings, vol. lxx, p. 432.

[2] Ibid., p. 435.

A similar effect may be produced in a different manner.[1] Such superincumbent drift will generally be porous, and more porous than the lost land-surface. Water sinking through this porous drift will sink to that old surface and find its way along that to the old hidden channels. Then flowing along these it will tend to erode subterraneously, and by the consequent land-sinkings it may produce a system of surface channels which will follow the lines of the former drainage system. I suppose the subsidences in the Cheshire salt-working district indicate hidden hollows of Triassic times: similar causes may lead to similar results.

Man makes reservoirs by dams across valleys; so Nature with landslips, moraines, lava-flows. When the water has risen above its dam, the river will commence to cut a channel through, and will resume its previous course. Sometimes, however, it is able to overflow across a lateral col: then the whole drainage system is altered; a lake replaces the old valley, and this begins to be silted up. Yet even now the valley may not be obliterated for ever. Allow sufficient time, the new channel will be cut down to the lake-floor, the lake will be empty: its bed will now seem a pair of opposite valleys meeting at a common outlet. What was depression before will be depression still. The result will be a physical feature such as we now see on the south-east side of the Mont Blanc chain. A vast moat extends below that mighty wall, from the Col de Ferret to the Col de Seigne, collects the whole drainage of the south-east face, and pours it out, opposite the central pass of the Col du Géant, through the sluice-like cleft where Courmayer stands. I do not affirm that the Allée Blanche was so produced; but an uprising of the Col de Seigne would have been able to produce it.

A lava stream down a valley would produce most serious alteration, even if it did not completely fill the trough, for the materials of the cast would be more resistant than those of the mould. Sometimes, indeed, erosion might go on along its edge, and create a new valley roughly parallel to the old. But lava-flows are exceptional agencies.

The depressions and re-elevations hitherto considered have been regarded as simple drops or lifts without tilt. It was convenient to keep separate the effects of deposition and the effects of altered inclination. Similarly, in considering the consequences of tilts, let us separate those which only alter the fall of the valley-bed from those transverse to them which alter the slope of the valley-sides. The former, if they increase the fall of the river, will increase erosion and deepen the valley; if they decrease it, will check deepening, may cause deposition to begin: they may reverse the flow, with erosion continued: they may create lakes, which may fill up parts of the valley. But very rarely can a valley by this means be so obliterated that every trace is lost.

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[1] Suggested by a friend in conversation.

Far different is the power of a tilt transverse to the stream-line. This will make one side of the valley more steep, the other less, and may thus go on to some extent without destroying the water-flow. But so soon as the angle of tilt exceeds the slope of the opposite valley-side, that slope becomes reversed; instead of shedding water down to the river-bed, it drains water away from it, and the valley is a valley no more. Its place in the scenery of the country is now taken by a feature which shows as a steeper slope with a gentler slope below: in profile like a cliff above a talus, or a river wall running along a river beach. But since a valley is rarely a straight trench, and a tilt can seldom be uniform, different parts will suffer in different degrees, so that traces of the trench may frequently remain. Those valleys will suffer most which are most nearly strike-valleys to the dip of the tilt. I suppose it has been already pointed out somewhere that, in a sinuous valley, the first effect of a tilt transverse to its general direction will be the creation of lakes on the lower sides of its windings.

I conclude, then, that the agents most able to efface a river valley are those which change the inclinations of strata; and that even these agents may effect considerable alteration in the surface without effecting a valley's destruction. But a powerful and incessant enemy is the river itself. For this in its sinuous lower course is ever tending to widen its trough, that is, to make the valley a less conspicuous feature of the relief. The valley opens out into an estuary; the estuary into a gulf, perhaps a sea.

'Permanence' does not precisely express the property which has here been discussed. This somewhat resembles a power of recovery from disaster, of awakening from hybernation or from sleep; an animal's reproduction of a lost limb; the regrowth of a broken crystal restoring its form. The valley shape may be lost for a while, but there remains a possibility of its restoration. We might almost talk of its vitality.

The valley retains its vitality, though its own river be burying it with sediment. Such sediment comes from the ridges between channels; the channels may be filling up while the ridges are being worn down, but if the channels are being cut, so also in general the ridges. Thus ridges may be the localities of more continuous degradation, and of irreparable destruction.

In view of this inherent vitality we may well believe some present valleys to be extremely ancient features of our earth's surface.

VI.—ON THE ORIGINAL FORM OF SEDIMENTARY DEPOSITS.[1]

By the Rev. J. F. BLAKE, M.A., F.G.S.

(*Concluded from the January Number, p.* 18.)

WE may now examine how far these theoretical conclusions explain and are confirmed by what is seen in nature. First we know that in most formations there are great masses of what is now, or must have been once, fine-grained sediment. These often make up the bulk of the formation. We may quote the Ordovician, Silurian, and Devonian slates, the Keuper, Lias, Oxford and Kimmeridge Clays, the Gault and London Clay; but we can give no such list of thick masses of marine sandstone. Fine sediment, therefore, has, as a matter of fact, made thicker masses of rock than coarse sediment; but this could not be the case if deposits thinned out seawards, where the fine sediment is carried. Again, it is impossible to imagine a thickness of a thousand feet and more constantly occupying a position near the shore; there is no room for it. If you depress the land, you remove the shore. To draw a diagram of one such deposit, an unnaturally scooped-out shore has to be assumed, and it is impossible to repeat the process. Indeed, a shape such as Fig. 2 is the only one possible for an indefinite number of deposits on a sloping sea-bottom. There is nothing, of course, to prevent a thinning out *beyond* the maximum, and a film from most terrigenous deposits does, no doubt, spread in that direction.

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[1] A paper read at the Meeting of the British Association, Belfast, September, 1902.

And if we go into details we find that where a thick deposit of fine sediment thins, we get independent evidence of an approach to a shore, but none where it remains thick.

Take the Cambrian and Ordovician strata as a whole. It has been found necessary by those who assume that a thickening of strata indicates approach to a source of supply to postulate a large continent occupying the position of the north part of the present Atlantic Ocean during those early times. But Mr. C. D. Walcott, the Director of the U.S. Geological Survey, writing on "The North American Fauna during Cambrian Time,"[1] states that "There is certainly no evidence to show that since the beginning of Palæozoic time the beds of the deeper seas have been elevated above the surface of the waters"; also that "The interior continental area [of North America] was outlined then ["at the beginning of Cambrian time"], and it has not changed materially since," and he draws a diagram accordingly, showing the Cambrian strata thickening as they leave the shores of this Pre-Cambrian continent. On this side of the Atlantic we learn from C. Schmidt[2] that in the Baltic provinces the whole of the Ordovician strata are represented by a thickness of 420 feet, whereas the same strata in this country are said to exceed 12,000 feet. Much of the latter may be of volcanic origin, but half the thickness would serve the present purpose. Now, speaking of the Scandinavian Ordovicians on the opposite side only of the Baltic, J. E. Marr[3] says: "Many of them [the fossils] are found in shallow water beds, deposited at periods when the greater part of the North-Western European area was covered with deep water"; and the fossils are certainly more abundant than in this country.

But these comparisons are on too large a scale. Let us take the case of a deposit laid down in a single basin and during a more closely defined period, such as the Upper Llandovery beds of Wales and the Shropshire area. We find that in the Malvern area the May Hill Sandstone is described as entirely conglomerate and sandstone, and of a thickness of at most 800 feet. At Rhayader, according to Mr. H. Lapworth,[1] the same group contains 200–300 feet of blue shales amongst the conglomerates, and 250 feet more above them. Thus, while the whole deposits have increased from 800 to 1,100 feet, the fine-grained detrital portion has increased from *nil* to 500 feet. Still farther west Mr. Walter Keeping,[2] who allowed as much as possible for folding, could not estimate his metalliferous slate group at less than 2,000 feet, and in this group he says that occurrences of grit, even of 2–6 inches thick, are very rare. His general conclusion is, "that whilst in . . . . the dawn of the Silurian era the elevatory forces lifted the sea bed to form a land surface over the west of England and the Welsh borders, these forces influenced the greater part of Wales only in a less degree," and did "not interfere with the continuous deposit of sediment." In other words, he recognizes that these deposits are thickest, independently of their character, at the greater distance from land.

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[1] U.S. Geol. Survey Ann. Rep., vol. xii, p. 563.
[2] Q.J.G.S., vol. xxxviii, p. 513.
[3] Q.J.G.S., vol. xxxviii, p. 513.

Take, again, the case of the Permians on the east side of the Pennine axis. They were deposited after the elevation of this axis, and towards the south end of their range there are indications of the shore-line both in the basal breccias and in the Magnesian Limestone. Near this shore-line the three members there found have a total thickness of 80–160 feet; but thirty miles away in the Searle boring the same beds (excluding higher ones there represented) have increased to 360 feet, to which increase the Magnesian Limestone makes only a negative contribution.

More interest in this regard attaches to the Jurassic rocks, as their thickness and character is more widely observable, and also because it was to these that Professor Hull appealed, on the assumption (for no shore-line was proved) that their "attenuation is due to the increase of distance from the sources of supply," to prove that their "sedimentary materials . . . . have come from land occupying the region of the North Atlantic."

The borings that have been made at Mickleton, Burford Synett, Wytham, and Turnford have certainly demonstrated the thinning out of all the Jurassic series and the Keuper towards the south and east; and as the slope thus produced is not greater than the angle of rest of the materials, it is competent for anyone to say that all the beds are in the position in which they were laid down (vertical elevation of the whole excepted), and that the sea bed beyond them to the east was too far removed from land to receive any of these terrigenous deposits. This, indeed, is what *must* be said if deposits thin out gradually seawards. But in this case we throw over the whole argument for a 'Palæozoic ridge,' and leave the fresh-water Purbecks of Buckinghamshire wholly unaccounted for.

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[1] Q.J.G.S., vol. lvi, pp. 69–135.

[2] Q.J.G.S., vol. xxxvii, pp. 141–150.

[3] Q.J.G.S., vol. xvi, p. 80.

But if, with Godwin-Austen, we account for the absence of Jurassic rocks over a wide area east of London, not by the area being too far from land, but by its being "dry land at this period," then the western side has been subsequently elevated, and the slopes which now are south-easterly were once north-westerly. We also have a proof that thicker beds as a whole correspond to deeper water, and that the original form of a sedimentary deposit as here described is the true one.

It is interesting to note what a difference in questions of palæogeography this interpretation of the form of a deposit makes. If we take Professor Hull's view, perhaps the most commonly accepted one, we read this general conclusion: "During the deposition of the Upper Palæozoic and Lower Mesozoic rocks an extensive tract of land existed to the north-west of the British Isles which afforded the materials of which these rocks are composed."[1] If, on the other hand, we take the view here put forward, apparently assumed but not definitely enunciated by Godwin-Austen, we are led to the conclusion that "The Oolites of Yorkshire and Lincolnshire were dependent on a land which lay to the east,"[2] and to the extension of this land on the map as far as the line of the North Downs.[3]

We may now test the supposed form of a sedimentary deposit by its effect upon the submarine contours. We have seen that this form involved the occurrence of a markedly rapid slope in the sea-bottom, corresponding to the seaward termination of the deposits. This slope might be at various distances from land, and affect various contour-lines, but more especially that of 100 fathoms.

In the case of the banks of coarser deposit in shallow depths, it is easy to see examples in the edges of the parallel roads of Glenroy, or in the undisturbed banks in dried-up lakes; and Godwin-Austen[4] states from actual survey that in the English Channel "the termination of deposits of a well-defined character, such as the shell-gravel beds or those of clean sand, is often by slopes more or less steep." Such banks and slopes, however, from being comparatively small and in shallow water, are easily altered by or confounded with the results of transverse currents.

It is, however, with the more extensive slopes which may mark the limit of deposits formed from sediment in suspension that we are most concerned. Possibly Godwin-Austen's observations apply to some of these deposits, as he compares them with escarpments of such when raised above sea-level, but in any case the great slope now referred to as the 'continental slope' has been known (*fide* G.-A.)

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[1] Hull: op. cit., p. 8.

[2] Godwin-Austen: Q.J.G.S., vol. xii, p. 64.

[3] Since this paper was read at Belfast, I have received the 21st Annual Report of the U.S. Geol. Survey, with an account of the Cretaceous formation of Texas by R. T. Hill. A full account is therein given of the thickening seaward of the Glen Rose formation (see pp. 138–9 and 369–382). This has been preserved from denudation by the overlying Fredericksburg Division, and is bounded below by the Palæozoic rocks. Its thickening is observed in artesian wells. It has thus retained its original form, which is 'wedge-shaped,' but the *termination* seaward I cannot find described.

[4] Q.J.G.S., vol. vi, p. 79.

since 1828 in its range between Cape Finisterre and the Lizard. Absence of anything that can represent the theoretical rapid slope cannot, therefore, be brought against the theory, but it is another thing to show that this actual slope has anything to do with the theoretical. This is what Godwin-Austen writes on this subject:[1] "Of the true nature of such a sudden line of depression we can at present only form conjectures. It may represent lines of old escarpments; or, should lines of sea-cliff have gone down rapidly into sea-water where no mechanical action could modify them, such features would be preserved; lines of faults and upheaval would also present such unequal soundings; but the outline is too irregular to represent the termination of the sedimentary mass of the present seas, besides which we have constant indications of a surface of bare rock." On this it may be remarked that the interpretation recently put upon this slope by Professor Hull, following the lead of Professor J. W. Spencer in America, had already been suggested as a possible one by the writer here quoted. We note also that the possibility of its representing the termination of deposits was admitted; but this interpretation was rejected for local reasons.

These reasons require an answer at once. The particular district to which the remarks of Godwin-Austen refer is one in which the result of sedimentation is masked by the irregularity of the previous sea-bottom. It is where the submerged continuations of Brittany and Cornwall project above the general submarine surface. Both countries are terminated with bosses of granite, and this feature is continued first in the islands of Ushant and Scilly, and then by a pair of banks on which granite fragments are found, hence the irregularity and the bare rocks in the region within the 100 fathom line.

But if we make comparisons in less exceptional localities we find remarkable confirmations of the idea that the slope is due to the termination of deposits. There is here copied (by his kind permission) a portion of the map[2] prepared by Mr. Hudleston for his paper "On the Eastern Margin of the North Atlantic Basin," which has the advantage of not being drawn for the purpose of proving the present theory (Fig. 3). Compare the lines marked *a–a* and *b–b*. The first is drawn directly outwards from the south-west of Ireland, south of the Shannon. Here there are no great detritus-bearing rivers, and the contour-lines are spaced with remarkable uniformity. The second is drawn opposite the opening of St. George's Channel, which may be considered as a large tidal estuary bearing much detritus seaward. Here the 100, 500, and 1,000 fathom contour-lines are much bulged outwards, while the spaces between the 1000–1500 and 1500–2000 lines are reduced to a minimum. Thus, where there is no deposit the continental edge is scarcely marked at all, and where we may suppose that there is much deposit taking place the slope is very sharp indeed.

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[1] Q.J.G.S., vol. vi, p. 86.

[2] Geol. Mag., 1899, Dec. IV, Vol. VI, Pl. III.

Again, compare the lines *c–c* and *d–d*. The first is drawn opposite the mouth of the Loire. Here the space within the 100 fathom line is very broad, while the other four lines down to 2,000 fathoms are crowded together into a quarter of the space. The second is drawn outward from the Pyrenees, and the slope is naturally rapid; but the spaces between the lower contours of 1,000 and 2,000 fathoms are together *twice* as broad as along the first line. Thus the deposits along the west coast of France have caused the continental slope there to be twice as rapid, instead of half as rapid, as it should be in comparison with the north coast of Spain.

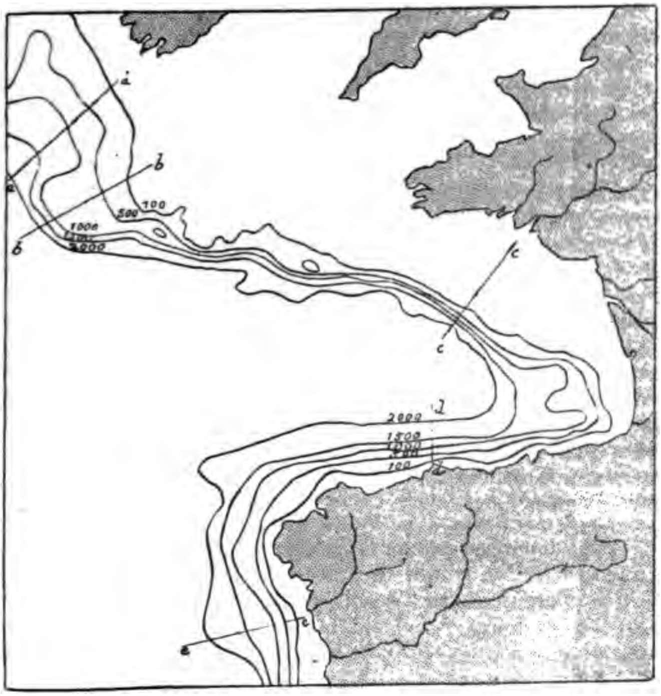

FIG. 3.—SUBMARINE CONTOUR-LINES FROM IRELAND TO PORTUGAL.

This apparent dependence of the breadth of the submerged shelf and the crowding together of the lower contour-lines on the existence of mud-bearing rivers, may be found repeated in many parts of the world where it is not obliterated by the redistributing power of the long-shore marine currents. The phenomenon is too universal to be assigned to submergence alone, though submergence in some places may modify or accentuate it, but must be the result of some ever acting but varying cause, such as the building up of new deposits from the materials denuded from the old.

The special effects upon the contour-lines immediately opposite the mouths of rivers can be demonstrated in many cases. Thus, no the map (Fig. 3) already quoted, the river Minho is an example. This descends almost straight from the mountains of Asturias, and has a short course. It is therefore rapid and muddy, and the line *e–e* drawn from its mouth outwards shows the deflection *towards* the shore of the upper contour-line and *from* the shore of the lower contour-line, in almost too exact conformity with the theory. The Douro, though a longer river, has not so rapid a descent, and the inflection of the contour-lines opposite its mouth do not go beyond that of 100 fathoms, and thus do not appear on the map, but the charts show a marked inflection of the 50, 80, and 90 fathoms contour-line. Such smaller inflections must be similarly looked for in closely surveyed charts, and will be found, for instance, all round the coast of India.

There is less reason to quote examples of the actual occurrence of this expected inflection, as it has already been dwelt upon by those who regard it as the indication of a submerged river channel. We have seen, however, that for the production of a depression opposite the river's mouth there is no necessity for the river to have *once* flowed *in* it, provided that the river-current *now* flows *over* it and protects it from deposit. From the instances thus quoted we must except the Congo, the gorge opposite the mouth of which appears to be due to the same cause which guided the river to its actual course. This is shown by the gorge extending up the river itself, "a depth of 150 fathoms being found 20 miles within its mouth."[1] This "is not due to erosion by the river, for the current, strong though it is, does not extend more than 20 fathoms from the surface." The author here quoted, who like Godwin-Austen has himself accompanied the sounding-line, is so much in accord with the theory propounded in this paper that a further quotation is much to the point. "The existence and persistence of the cañon are due to an agency which prevents the mud brought down by the river being deposited along its axis. . . . . The bottom of the cañon, or gully, would thus resemble more nearly the original form of the bottom of the sea before the Congo discharged its waves into it than the flatter and shallower bottom on each side of it. In fact, the cañon has been built up, not hollowed out. In how far a crack in the crust of the earth may have had to do with the depth and position of this cañon it is impossible to speak certainly, but the preservation and accentuation of it are certainly due to the prevention of the deposit of sediment." This recognizes the agency here invoked, but does not apply it to the *production* of the gorge. It could not, in fact, have produced the whole of it, as the bottom of the shallower sea at the sides is marked in many places within forty miles of the land as 'stony.'

The bulging seawards of the lower contour-lines can only be looked for in large rivers or currents, or in specially rapid ones on quickly sloping shores: otherwise they are liable to be modified by oceanic currents. But a very remarkable bulge is seen in the case of the La Plata, opposite the mouth of which the chart accompanying the Summary of Results of the *Challenger* Expedition shows a broad seaward deflection of the 2,000 fathom line. It is, of course, very difficult to assign every peculiarity of a contour to its proper cause, but in this case there is no remarkable submarine bulge along the whole eastern coast, except where theory would lead us to expect it. In the north coast there is also a longer bulge, corresponding to the Amazon, but driven westward by the equatorial current.

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[1] J. G. Buchanan: Scottish Geogr. Mag., vol. iii, p. 222.

If the differences of depth near coastlines are due to the deposition or non-deposition of sediment, we might expect that where long-shore currents do not interfere the *lateral* boundary of a deposit should also be marked by a slope, and the interval between deposits from different sources by a broad channel. In this way we may *suggest* a reason for such peculiar features as the 'Fosse du Cap Breton,' 'the Baltic River,' and the 'Swatch of no ground.' The first of these may be the interval between the deposits from the Loire and Gironde and the slopes of the Pyrenees, where there is little deposit; the second, between the wide and ancient deposits which have covered the North Sea from the Elbe, Rhine, Thames, etc., and the almost unaltered boundary of South Norway; and the third, between the deposits reaching the Indian Ocean by way of the Hoogly and by way of the Brahmaputra respectively.

The views here propounded may now, I think, claim to be supported, not only by *a priori* arguments, but by many undeniable facts of nature of which they offer an explanation, and by several first-hand observers who have been led to adopt some part of them at least, as occasion served. But they are subversive of common assumptions in so far as these are applied to uniform deposits, and they alter entirely our means of interpretation of the sources of any stratum. The 'continental slope' has been called an escarpment, though the term was afterwards withdrawn; but according to these views it *is* an escarpment, but with this difference: it is an escarpment yet to be. When the marine deposits have been raised above sea-level and we stand facing the escarpment, we may be looking at the actual end of the deposit, except for later weathering backwards, and we must look along the present dip slope towards the land whence the material of the strata has been derived.

When limestones give place along the strike to clays we must not look for the shore in that direction, but in a direction perpendicular thereto, nor must the sea be supposed to have been deeper beneath the limestone, but possibly shallower, the unevenness of the sea-bottom having caused the clays to be deposited elsewhere.

Neither must we regard the existence of a well-marked continental slope as a proof of depression, it may be of 6,000 feet or less, of a land of great mobility; but look on it as a proof of stability, which allowed the slowly deposited sediments to retain the same limit for so long a time. The existence of the continental slope in this way speaks against the hypothesis of a glacial submergence.

On the other hand, we must be careful not to push theoretical results beyond their proper limits. Deposits may be altered in shape by various causes before we can examine them: currents may deflect the deposits from where we should expect them: and not all the contours of the sea-bottom are caused by deposits alone. All that can be said is that the tendency of uniform deposits to thicken before ceasing must always be present, and must modify any result which may be due in part to other causes: while under some circumstances this cause may be expected to be the only one which gives the deposit its form.

VII.—On two Sections of the Rhætic Rocks in Worcestershire.

By L. Richardson, F.G.S.

A DESCRIPTION of two Rhætic sections forms the subject of this communication. In a county where but one section has been described this is a considerable addition to our knowledge of the series. It is remarkable that the section at Crowle has not been previously noticed; it may be easily examined, and not like the only recorded section in the railway-cutting at Dunhampstead, which is necessarily difficult to obtain access to. The Crowle section is situated at the junction of the road from Oddingley with that from the house marked as "Frisland" on the Geological Survey map. The beds are affected by a fault having a downthrow of about 14 feet.

Section at Crowle, near Worcester.

			ft.	ins.
Lower Rhætic, or Zone of *Avicula contorta*.	7.	Shales, black.		
	8.	Sandstone, yellowish-white.		
	9.	Shales, brown, imperfectly laminated; uppermost 4 ins. black	1	2
	10.	Sandstone, several layers separated by shaly partings; *Gyrolepis Alberti*, teeth of some actinopterygian fish (possibly *Gyrolepis*), annelid-tracks, ripple-marks, and a vertebra	0	9
	11.	Shales, black; numerous sandstone layers, uppermost 3 ins. brown	1	8
	12.	Sandstone (Bone-bed-equivalent), yellowish-white, micaceous, fissile; *Schizodus* (casts), ripple-marks, and annelid-tracks	1	1
	13.	Shales, black (weather grey), laminated, arenaceous towards base	2	11
	14.	*a.* Sandstone, yellowish-white, micaceous, fissile; casts of *Schizodus* somewhat abundant — especially in the lowest layer	0	6–8
		b. Sandstone layers with shaly partings	0	2–3
		c. Yellow clayey deposit	0	1
Upper Keuper.	I.	'Tea-green Marls.' Creamy white and slightly green marls with three harder bands of marlstone: estimated at ...	31	0
	II.	Red marls with bluish zones and blotches.		

The 'Tea-green Marls' are well exposed, and comprise creamy white marls, slightly green in places, with harder bands, the marlstone composing these harder bands having a most irregular fracture. At the base of the Rhætic is a yellow clayey deposit in which no organic remains were observed. The junction of the Rhætic and Keuper series is sharply defined, as is also the case in North-West Gloucestershire. About 3 inches of thin sandstone layers with intercalations of shaly matter separate this yellow clayey deposit from a more massive bed of sandstone, in the bottom layer of which casts of *Schizodus* are somewhat abundant. In the black shales which succeed no fossils were observed, but they, in common with the rest of the beds in this section, have suffered much from atmospheric influences. These shales are capped by a massive bed of sandstone, the equivalent of the true Rhætic Bone-bed. In North-West Gloucestershire this bed undergoes numerous lithic changes; for example, in the cliff section at Wainlode, near Gloucester, it passes from a thin hard pyritic bed, replete with fish scales and teeth, into a non-ossiferous sandstone about a foot thick. In the latter form it is visible in the shallow cutting on the Tewkesbury and Ledbury road at Bushley, and again at Bourne Bank, near Defford, where it has increased in thickness to 2 feet. Another exposure of the same bed is obtainable in the lane cutting ¾ mile north of Croome D'Abitot Church, and is seen to be separated by 2 feet 10 inches of black shales from the 'Tea-green Marls.' No more good exposures are afforded until we reach Crowle; but in the intervening area another deposit of sandstone has made its appearance, separating the black shales from the Upper Keuper marls. The maximum thickness of this arenaceous deposit is 1 foot, and in the railway cutting at Dunhampstead, near Droitwich, permission to examine which was kindly given me by the Midland Railway Company, it is about the same. On the eastern borders of the county at Marl Cliff, however, no such deposit is present, and the Bone-bed-equivalent, under an inch in thickness, rests upon 2 feet of black shales, and this latter deposit upon about 24½ feet of 'Tea-green Marls.' With a development of the Bone-bed, such as that at Marl Cliff, we might, from experience, have expected to see it highly ossiferous, but, excepting a very few fish scales, such is not the case. Indeed, the only locality in Worcestershire where a really ossiferous Bone-bed has been observed is at Hob Lench, and Mr. R. F. Tomes, F.G.S., informed me that Mr. Kershaw and he obtained from a well here the specimens now in the Museum of the Victoria Institute at Worcester, presented to that Museum by Mr. Tandy.

To return to the Crowle section, 1 foot 8 inches above the Bone-bed-equivalent is a series of sandstone layers separated by shaly partings, collectively 9 inches in thickness, and constituting the most fossiliferous deposit in the section. It was in what I consider to be the equivalent deposit at Deerhurst that I found a new species of *Heterastræa*; the only authentic record, I am told by Mr. Tomes, of a coral from the zone of *Avicula contorta*. The other section to be noticed is in the Duke of Orleans' grounds at Woodnorton, near Evesham. At the hill locally known as the 'Blue Hill' a bridle-path passes through a cutting under a public road. Mr. Wasley, Head Keeper to the Duke of Orleans, kindly conducted me to the section. The bank had been smoothed down and the section was rapidly becoming obscured, so that it was impossible to examine the shaly deposits for fossils. The limestone bands, however, were very prominent.

SECTION AT WOODNORTON, NEAR EVESHAM.

		ft.	ins.
LOWER LIAS (*pre-planorbis*).	Limestone, bluish-grey; *Ostrea liassica*	0	3
	Clay, yellowish, marly	2	7
	Limestone, in two layers, bluish-grey, shelly; *Ostrea liassica*, *Modiola minima*	0	4
UPPER RHÆTIC.	1. Shales, brown, thinly laminated	2	0
	2. Limestone, hard, bluish-black; *Modiola minima*	0	5
	3. Shales, grey and greenish-grey, laminated in places, usually non-laminated, marly ...	5	4
	4. Limestone (*Estheria*-bed), creamy yellow, argillaceous; *Estheria minuta* var. *Brodieana*, *Naiadita lanceolata*	0	3–5
	5*a*. Shales, grey, greenish-grey, and yellowish, thinly laminated in places, usually non-laminated, marly; shell fragments	14	6
LOWER RHÆTIC, or Zone of *Avicula contorta*.	5*b*. Shales, dark-coloured		
	6. Limestone nodules, containing *Schizodus Ewaldi*; resting upon a laminated limestone full of shell fragments; *Pecten valoniensis*, *Schizodus Ewaldi*, *Protocardium*, and *Pleurophorus* ...	0	8
	7. Shales, black, laminated ... ... (visible)	0	6

This section is the only one of the Upper Rhætic stage in the county, and accordingly is of considerable importance. At Wainlode Cliff the Upper Rhætic is 13 feet 4 inches in thickness, here it is about 19 feet 7 inches, i.e., deducting 3 feet from the thickness of the lowest deposit of the upper stage, which would probably be found to belong to the *Avicula contorta* zone or Lower Rhætic had it been possible to investigate it for fossils.

Concerning the nature of the deposit above the beds exposed at Crowle and below those seen at Woodnorton the section at Dunhampstead affords some assistance. These intervening beds at Dunhampstead are as follows:—

		ft.	ins.
LOWER RHÆTIC.	6. Limestone nodules	0	10[1]
	7. Shales, black, clayey, pyritic (4 feet less 1 ft. 5 in.)	2	7[1]
	8. Sandstone, brown, micaceous; *Modiola minima*, *Schizodus* ...	0	3
	9. Shales, brown, clayey	1	2
	10. Sandstone, yellowish (weathering brown), micaceous; *Modiola minima*, *Schizodus*, annelid-tracks, fish scales	0	5

If this record be read with those made at Crowle and Woodnorton, a generalised section will be had of the Rhætic series as it occurs in Worcestershire.

VIII.—SCRATCHES ON MINERALS IN THIN SECTIONS.

By H. STANLEY JEVONS, M.A., F.G.S., Lecturer in Mineralogy and Demonstrator in Geology in the University of Sydney.

THERE is an exceedingly simple method of distinguishing biotite from brown hornblende in thin sections under the microscope, which, so far as I am aware, has not yet been described. As it may possibly be of assistance to beginners, I submit a brief account thereof.

Let any section of biotite which shows the cleavage and pleochroism be turned between crossed nicols until the light is almost, but not quite extinguished. When closely examined with a low power it will be seen to be irregularly speckled with small spots and patches of light, generally oval or elongated in shape, which often give its surface a rough or shagreened appearance. These spots are still visible if the section be turned to complete extinction, and are then cut in two longitudinally by a dark line. If the section be further turned to the other side of the position of extinction they resume their original shape, but are seen to have changed their position slightly.

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[1] On authority of Mr. W. J. Harrison, F.G.S.: *vide* Proc. Dudley and Midland Geol. Soc., vol. iii, No. 5 (1877), p. 121.

The cause of this want of uniformity in extinction is easily ascertained by examination with a high power. Wherever these light spots occur the cleavage lines are seen to be bent laterally from their normal course into a V-shape, doubtless by the scratching action of the coarser grains of the polishing material during the final stage in the grinding of the section. The V's piled upon one another simulate a cross section of a pointed anticline or syncline of great vertical range.

It is evident, therefore, that when the section as a whole is at its position of extinction, the mica along both arms of the V lies in such directions that light will get through it. The dark line before mentioned as cutting the spots longitudinally when the section is in this position passes through the apices of the V's, and is due to the fact that between their two arms the mica must lie for a short distance in its original direction, now the direction of extinction.

The spots are brightest, however, when the section as a whole is not quite extinguished, for then one arm of the V is completely extinguished, whilst the other is well on towards its position of maximum illumination. On turning the biotite from one side to a similar position on the other side of its direction of extinction the effect is similar, but reversed; what was previously the darker arm of the V has become the lighter, and *vice versâ*. The same effect is visible in less marked degree with only one nicol in use, on account of the strong pleochroism of biotite. The angular displacement of the arms of the V is sufficient distinctly to alter the amount of absorption.

The appearance described is presented, in my experience, only by such minerals as are soft, and have a very good cleavage. It is visible in biotite, muscovite, and talc, and a few other soft minerals rare in rock sections. Practically, every section of these minerals which I have examined shows the effect, excepting those parallel to the cleavage, and I have *never* seen it in hornblende or any member of the pyroxene or amphibole family.

If the attention of the beginner has once been called to these scratches, he never mistakes hornblende for biotite; and only under the rarest circumstances connected with the preparation of the section could he mistake biotite for hornblende, even if relying solely on this test. To the more advanced student the appearance may occasionally prove of service in the identification of minerals, as evidence of their softness.

IX.—Note on an Unmapped Toadstone Bed in the Derbyshire Mountain Limestone.[1]

By Samuel Moore, Esq.

IN the Summer of 1901 I found in a pasture, between Oxlow Rake and Cop Round (IX S.E.), some blocks of Toadstone in a bed of clay that has all the characteristics of decomposed Toadstone. The clay was being dug for puddling a new mere, and the deposit is well known to natives. I traced the outcrop south-west to Starvehouse Mine, and my inference that the clay was decomposed Toadstone was soon verified by the Toadstone itself coming to daylight and replacing the clay. I did nothing more that year, but in the Summer of last year I continued to follow the bed, and have traced it as far as Bushy Heath House (XV N.E.), a distance of about two miles from its starting-point.

The outcrop starts as a clay bed, at the southern end of an enclosure called Old Moor (IX S.E.), at a point about 50 yards south-east of two old mine shafts, and where a spring issues from under the limestone scarp, at a height of 1,400 feet above mean sea-level (by aneroid). Thence it runs in a general south-west direction for half a mile, along a line of five springs at the base of the limestone escarpment, to the north wall of Starvehouse Mine (IX S.E.), which it cuts at an altitude of 1,500 feet.

There is no throw at the Starvehouse lode, and the bed contours round the point of Cop Round and crosses Dick Lane 30 yards from the summit gate (1,510 feet); from there it runs south-east with the dip of the limestone to Moss Rake (IX S.E.), the base passing just above the letter *n* of Piece Barn on the map. It reaches the lode at 1,350 feet. Here the bed is faulted and thrown up to the north, and the top starts afresh about 180 yards up the lode, at an altitude of 1,420 feet.

The top then runs, along the base of a limestone scarp, to a point beneath the Old Roman Camp on Batham Gate (IX S.E.), crosses the road at the gate to The Holmes (XV N.E.), and runs down, through the farmyard, to the continuation of the Shuttle Rake lode, below the old Calve Stones Mine plantation.

There appears to be no fault at this lode, but the bottom of the valley is flat and filled with superficial deposits which conceal the outcrop.

From The Holmes the bed is traceable still in a general south-east direction, as far as an old quarry (XV N.E.) at an altitude of 1,300 feet, and 300 yards N.N.W. from Bushy Heath Farmhouse. From there to Chap Maiden Mine (1,276↗) the traces are indistinct, owing to flat ground. Beyond this point I have not at present traced it, but next Summer I hope to do so.

The bed of Toadstone here described lies above the topmost bed shown on the 1 inch map of the Geological Survey, and is separated from it by nearly 150 feet of solid limestone. It varies in thickness:

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[1] See Geol. Surv. Map 81 N.E., original 1 inch scale; Maps IX S.E. and XV N.E., 6 inch Ordnance Survey.

at the start on the Old Moor I should put it at 15 or 20 feet of clay, but it thickens in a south-west direction, and at Cop Round I estimate it to be 60 to 80 feet thick, which thickness it maintains up to the Moss Rake. After that it seems to thin out; but just above The Holmes and beneath the Roman Camp it crops out strongly again and is about 80 feet thick, if not more. From The Holmes to Bushy Heath I could not ascertain the thickness. At Cop Round some blocks are concretionary, and I have not noticed any columnar structure. The bed seems to decompose into clay very freely where it is not thick.

I wish to draw attention to this bed of Toadstone because I think it will be of importance in the stratigraphy of the Toadstone beds near Tideswell, Litton, and Wheston; and further, in order that the bed may not be overlooked in any future resurvey of the country: it is not a prominent bed like the one immediately below it.

With regard to this latter bed I may as well point out what strikes me as an error on the part of the Geological Survey. On their 1″ map 81 N.E. the bed is made to start at a point between Eldon Hole (IX S.E.) and the summit of Eldon Hill, at 1,480 feet altitude, where the limestone beds dip true E. 40° S., at an angle of 6°; it is then drawn to run down into Cunningsdale, round Oxlow, across Oxlow Rake to Oxlow Dam, and on to The Cop Farmhouse. In the length between Eldon Hill and Oxlow Dam I cannot find any evidence of an outcrop of Toadstone, or even of clay that might be decomposed Toadstone. As one traces the bed westward from The Cop Farmhouse (IX S.E.) it appears to thin out, and vanish at a spring just outside the south-west corner of Starvehouse Mine. Moreover, the line as drawn in its descent from Watts Plantation (IX S.E.) to the bottom of Cunningsdale, and in its ascent again to Oxlow Rake, does not follow the dip, but cuts across the limestone beds in a manner not usual with the Toadstone in this part of the country.

REVIEWS.

I.—THE PALÆONTOGRAPHICAL SOCIETY OF LONDON.

THE ANNUAL VOLUME OF THE PALÆONTOGRAPHICAL SOCIETY FOR 1902: Vol. LVI. 4to. (London: printed for the Society. Dulau & Co., Agents for the Society, 37, Soho Square, W. Price to Subscribers 21*s.* per annum.)

AGAIN it is our pleasant task to welcome the issue of another volume (larger than usual) of this Society's admirable publications, which has for its object the description and figuring of all the known British fossils.

When its heroic founders set out on this enterprising task, nearly sixty years ago, they were doubtless as courageous as Jason and his Argonauts when they set sail in the good ship *Argo* to fetch the golden fleece; but, like Jason and his Grecian heroes, they must soon have found that they had undertaken a very arduous task; many of the brave workers have died since then, yet the task still remains unfinished. Yet notwithstanding our losses, the heroes of our modern *Argo* are an indomitable body, and its ranks are ever being renewed by fresh palæontological volunteers.

In our last number we recorded the death of our late Secretary, Professor Wiltshire, who for 36 years had carried on the administration of the Society. His place is now filled by Dr. Arthur Smith Woodward, F.R.S., while many new contributors (himself among the number) have been added to our body.

In the present volume Professor S. H. Reynolds takes up the unfinished work on "The Pleistocene Mammalia," commenced by Messrs. Boyd Dawkins & Sanford in 1864, and continued till 1871; since then, with the exception of a short account of the Pleistocene Cervidæ by Professor Boyd Dawkins in 1886, the original authors have abandoned their work, which is now taken up by Mr. Reynolds. The present fasciculus forms part 1 of vol. ii, and is devoted to "The Cave Hyæna," the illustrations being mostly taken from the wonderful series of Hyæna remains from Wookey Hole in the Mendips, now preserved in the Taunton Museum. Six out of the fourteen plates were executed long ago by the late Mr. W. Bidgood, formerly curator of the Taunton Museum; the others are newly drawn by Mr. J. Green, one or two from the British Museum collection and others from that of Owens College Manchester. The Society is to be congratulated upon securing the services of Professor Reynolds for this important work on vertebrate palæontology.

The next monograph is a new one on the "Fossil Fishes of the English Chalk," by Dr. Arthur Smith Woodward, and is illustrated by thirteen very fine plates by Mr. A. H. Searle and twelve drawings and restorations of *Eurypholis*, *Odontostomus*, *Chlorophthalmus* (recent), *Sardinioides*, *Hoplopteryx* (*Beryx*), *Beryx splendens* (recent), *Berycopsis elegans*, *Aipichthys*, admirably drawn by Miss G. M. Woodward. One plate is an autotype of a group of Chalk fishes of the genus *Hoplopteryx* from the Beckles Collection in the British Museum, by Mr. Green. Fifty-six pages of descriptive letterpress are issued with this very important memoir.

The third monograph is a continuation of the "Cretaceous Lamellibranchia of England," by Henry Woods, M.A., part iv being devoted to the Chalk Pectens. The twelve plates are very ably rendered by Mr. Hollick.

The concluding monograph is a continuation of that on British Graptolites by Gertrude L. Elles & Ethel M. R. Wood, edited by Prof. Charles Lapworth, F.R.S. There is an interesting introduction and the following genera are described and figured: *Tetragraptus* *Schizograptus*, *Trochograptus*, *Holograptus*, *Dichograptus*, *Loganograptus*, *Clonograptus*, *Temnograptus*, *Bryograptus*, *Azygograptus*, and *Phyllograptus*. We confess to a feeling of disappointment in the production of the very careful original drawings by process in these plates. We prefer an accurate, clear, distinct *outline* to each figure We are quite sure these are *most accurate*, but they are neither so clear nor so distinct as we could desire; and there is a dread that this highly-surfaced paper will, after some years, perish, being overloaded with kaolin. There are quite a number of process-blocks in the text, some of which give *most clear details*, such as we desire, but others are less satisfactory. We look back with admiration to Professor Lapworth's own original drawings in this Magazine, the Quart. Journ. Geol. Soc., and elsewhere, which are to our minds more satisfying, notwithstanding the great labour which the authors have expended on the present monograph.

Taken as an annual issue, this is a fine volume, containing, as it does, 207 pages of descriptive text, 47 plates, and numerous illustrations in the text, together with 30 pages of introductory matter, the whole of which can be obtained for the small subscription of one guinea.

We expect to find that, after this announcement, Messrs. Dulau & Co., 37, Soho Square, and the Secretary, Dr. Arthur Smith Woodward, will have a busy time in satisfying the demands of the many new and enthusiastic subscribers who will send in their names and cheques!

II.—Sherborn's Index Nominum Animalium, 1758–1800.

Index Animalium, sive index nominum quæ ab a.d. mdcclviii generibus et speciebus animalium imposita sunt societatibus eruditorum adjuvantibus, a Carolo Davies Sherborn, confectus, sectio prima a kalendis januariis mdcclviii usque ad finem Decembris mdccc. Cantabrigiæ e typographio academico mdcccciI. Roy. 8vo; pp. lix, 1196. (London: C. J. Clay & Sons, Cambridge University Press Warehouse, Ave Maria Lane, 1902. Price 25*s.* net.)

THE Syndics of the Cambridge University Press having undertaken the publication of the first part of the "Index Animalium," to the preparation of which Mr. C. Davies Sherborn has devoted so many years, it seems desirable to explain the nature of the work upon which so much time, labour, and expense have been bestowed. The object of the Index is to provide zoologists with a complete list of all generic and specific names given by authors to animals, both recent and fossil, since January 1st, 1758, the date of the tenth edition of Linnæus' "Systema Naturæ." With each name is given an exact date, and a reference intelligible to the layman as well as to the specialist.

The British Association appointed a Special Committee to watch over the inception and progress of the work, the preparation of which was undertaken in 1890.[1] Financial support has been given by the British Association, the Royal and the Zoological Societies, while the authorities of the British Museum (Natural History) have afforded continual assistance.

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[1] An interval of three years was unfortunately lost by the author from ill-health, so that the completion of this first volume has occupied a period of eight years, a no inconsiderable task for one man to undertake and carry through to completion.

Similar works have been produced before, but no one book has yet appeared attempting to supply references to all names given to both fossil and recent animals, nor has any definite attempt been made heretofore to fix an accurate date to each name.

This work will, of course, supersede Agassiz and Scudder, and must be absolutely indispensable to zoologists of all countries. It will be to the student of animal life what the "Index Kewensis" is to the botanist, and, indeed, far more, as the last-named work refers only to Phanerogams, whereas the "Index Animalium" includes all groups of animals, and both recent and fossil forms. The portion of the work already completed and now issued from the press of the University of Cambridge covers the period from 1758 to 1800, consists of 61,600 entries, and fills 1,196 pages royal octavo.

In 1897 Dr. Sclater suggested to the Committee that, in view of the long time that must elapse before the completion of the whole manuscript, which it was proposed should embrace the period from 1758 to 1900, it would be well if a portion were prepared and published as a specimen of the whole. This suggestion has been acted upon, and there is now offered to the consideration of zoologists that part covering the years 1758 to 1800 inclusive. During the progress of this earlier portion of the manuscript it became apparent that a great deal of the literature required was not to be found in England, and it is satisfactory to be able to say that, with a few unimportant exceptions, the bulk of the 1,300 volumes required have either been seen, or else seen and acquired for some one or other of the libraries accessible to the public. "The search for these volumes," says Mr. Sherborn, "has been not the least interesting part of my labours. Such as have eluded my search are mentioned in 'Libri desiderati,' where a complete enumeration of the books consulted has been given in a second list, this seeming to be advisable and useful; and at the same time such notes are given on them as would be of use to those who might wish to consider or purchase them."

"I would like to say that, with the exception of some fifty entries kindly made for me by my friend Dr. Bather in Stockholm, and by Professor Perez in Bordeaux, every entry has been recorded from the original, arranged, sorted, checked, and passed for press by myself. I therefore beg the indulgence of those who use this book for any error of commission or omission that may be found. And I may add that a note of any such error will be especially valuable for inclusion in the second part of my 'Index Animalium.'"

We heartily commend this important work to the attention of all librarians, curators, and zoologists in all the world, for none can work without it. It is like the "Postal Guide," "Bradshaw," or "Whitaker's Almanac," a handy book of reference, containing the scientific names of beasts of all kinds, and must be on the bookshelf of every library embracing Natural History.

We earnestly hope the author's valuable life may be spared to see the completion of the next century of his Index through the press, the manuscript for which is already far advanced.

The later years will be not only of far greater importance to zoologists, but will be a thousandfold more prolific in the number of works to be referred to, and of the objects described in them, than those of the previous half-century. We compliment the author on the grand volume he has produced, and the Syndics of the Cambridge University Press for having printed it in so accurate and admirable a manner.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 3rd, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Well-sections in Suffolk." By William Whitaker, Esq., B.A., F.R.S., F.G.S.

Notes of thirty-one new wells have accumulated since 1895, some of them giving results which could not have been expected. A trial boring for the Woodbridge Waterworks Company gave a depth of 133¾ feet down to Eocene beds, and a thickness of Crag about double of any before observed in the neighbourhood. An analysis of the saline, hard water yielded is given. Three explanations are suggested: a channel, a huge 'pipe' in the Chalk, or a disturbance such as a fault or a landslip; but the author is not satisfied with any of them. Two borings at Lowestoft show that Crag extends to a depth of 240 feet in one case and over 200 feet in another, confirming estimates of Mr. Harmer and Mr. Clement Reid. In one of these, Chalk was reached at 475 feet. Three other wells in the neighbourhood confirm the great depth of the newer Tertiary strata. Sections are also given from the following places:—Boulge, Hitcham Street, Ipswich (corroborating the evidence for a deep channel filled with Drift given by the section at St. Peter's Quay, New Mill), Shotley, Stansfield, and Brettenham Park. The last shows the greatest thickness of Drift recorded in the county, namely, 312 feet.

2. "The Cellular Magnesian Limestone of Durham." By George Abbott, Esq., M.R.C.S., F.G.S.

The Permian Limestone covers about 1¼ square miles near Sunderland; it alternates with beds of marl containing concretionary limestone-balls, and attains a thickness of 65 feet or so. The cellular limestones frequently contain more than 97 per cent. of calcium-carbonate. Magnesium-carbonate occupies the interspaces or 'cells' of this limestone, and also the spaces between the balls. The hundred or more patterns met with in it can be arranged into two chief classes, conveniently termed honeycomb and coralloid, each with two varieties; and each class has four distinct stages, both classes having begun with either parallel or divergent systems of rods. The second stage is the development of nodes at regular distances on neighbouring rods; and these in the third stage, by lateral growth, become bands. Finally, in the fourth stage the interspaces become filled up. The upper beds are usually the most nearly solid. In the coralloid class the nodes and bands are smaller and more numerous than in the honeycomb class. In both classes tubes are frequently formed. The rods have generally grown downwards, but upward and lateral growth is common. A section of Fulwell Quarry is given.

II.—December 17th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "Note on the Magnetite Mines near Cogne (Graian Alps)." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

These mines have been worked probably since Roman times, but are now almost deserted. They are situated in the Val de Cogne, one of the larger tributaries of the Val d'Aosta from the Graian Alps. The author, in company with the Rev. E. Hill, last Summer examined two localities where the ore has been worked. At one, the Filon Licone, the mass of magnetite is probably about 80 or 90 feet thick and some five times as long. At the other place, the Filon Larsine, the mass apparently is not nearly so thick. The ore is a pure magnetite, jointed like a serpentine, a thin steatitic film being often present on the faces. At both localities the magnetite is found to pass rapidly into an ordinary serpentine, the transitional rock being a serpentinized variety of the cumberlandite described by Professor Wadsworth in his "Lithological Studies." The serpentine is intercalated, like a sill, between two thick masses of calc-mica-schists, with which green schists (actinolitic) are as usual associated, no doubt intrusively. All these represent types common in the Alps. The author discusses the relations of the magnetite and serpentine, which, in his opinion, cannot be explained either by mineral change or by differentiation *in situ*, but indicate that a magnetitic must have been separated from a peridotic magma at some considerable depth below the surface, and the former, when nearly or quite solid, must have been brought up, fragment-like, by the latter; as in the case of metallic iron and basalt at Ovifak (Greenland).

2. "The Elk (*Alces machlis*, Gray) in the Thames Valley." By Edwin Tulley Newton, Esq., F.R.S., F.G.S.

During the construction of the Staines Reservoirs some mammalian remains were obtained from the alluvium of the Wraysbury River, near the Thames at Youveney. At the request of Mr. T. I. Pocock, of the Geological Survey, who is working in the district, the engineers, Messrs. Walter Hunter and R. E. Middleton, courteously submitted their specimens to the author, who recognized among them the skull and antlers, with other parts of the skeleton, of a true elk (*Alces machlis*). These are described; allusion is made to the earlier records of this animal in Britain; and its distribution in time in this country, on the continent of Europe, and in North

America is also discussed. It appears that *Alces machlis* has been frequently found in peaty deposits in many parts of Great Britain and on the continent of Europe, but never in Britain in association with the mammoth; and it seems probable that in Europe and North America it was a rare animal in Pleistocene times, if indeed it was present before the close of that period.

3. "Observations on the Tiree Marble, with Notes on others from Iona." By Ananda K. Coomáraswámy, Esq., B.Sc., F.L.S., F.G.S.

The gneiss near Balephetrish has a general south-westerly and north-easterly trend, and the limestone occurs in it as lenticles of various sizes, having a similar foliation. Descriptions of pink, grey, and white varieties of the limestone in this locality are given. The inclusions comprise those of gneiss containing quartz, felspars, hornblende, augite, scapolite, and sphene as characteristic minerals, and mineral aggregates consisting of sahlite, coccolite, scapolite, sphene, apatite, calcite, and mica. The contact-phenomena are not specially well displayed, but several instances are described; and in these the minerals of the modified gneiss interlock with those of the modified limestone, and there is no actual line of junction seen under the microscope, although an abrupt change is evident. The dynamic phenomena include the rounding of the minerals (frequently, however, an original character) and the formation of 'augen.' The carbonates are present as a fine-grained granular matrix, the result of the breaking down of larger grains, probably at a temperature not above 300° C., as indicated by the experiments of Adams and Nicolson. Although there are exceptions, gneiss-inclusions and mineral aggregates have usually been protected from the effects of extreme pressure. The description of minerals includes carbonates, pyroxene, amphibole, forsterite, scapolite, sphene, mica, apatite, and spinel. White, greenish, and black marbles are described from Iona, where they are associated with actinolite-felspar-schists and others; they are included in the gneiss. Sedimentary rocks suggestive of Torridon Sandstone occur along the eastern shore of Iona.

III.—January 7th, 1903.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communication was read:—

"On the Discovery of an Ossiferous Cavern of Pliocene Age at Dove Holes, Buxton (Derbyshire)." By William Boyd Dawkins, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology in Owens College, Victoria University (Manchester).

The Carboniferous Limestone, riddled with fissures and potholes, in the neighbourhood of Dove Holes, has from time to time, in the course of the working of the quarries, yielded remains of extinct mammalia of Pleistocene age. The latest discovery of a group of mammalia, of far higher antiquity than the Pleistocene, is now brought before this Society. The Victory Quarry, Bibbington, in which the discovery was made, is excavated in a rolling plateau of

Carboniferous Limestone, from 1100 to 1200 feet above Ordnance-datum, and forming at this spot the water-parting between the tributaries of the Goyte, flowing past Chapel-en-le-Frith westward into the Mersey, and those flowing southward and eastward, past Buxton, to join the Derwent. It is a little to the north of the centre of the divide. On the western side the limestone dips at an angle of 15° underneath the Yoredale sandstones and grit, which form the lower half of a range of hills, extending southward to Buxton and beyond. The upper half is composed of shales and sandstones of the Millstone Grit Series, that rise in Black Edge to a height of 1662 feet. The drainage of the eastern slope of these hills passes downward, until it arrives at the limestone, where it sinks into the rock, through the many swallow-holes which mark the upper boundary of the limestone. There are no surface streams in the limestone in the immediate neighbourhood of the Victory Quarry, which, from its position on the divide, could not, under existing geographical conditions, receive the drainage from this western range of hills or any other source.

In the course of working the quarry, in the beginning of 1901, a cave was discovered, and fully exposed in the course of 1902. It was about 90 feet long, 15 feet high, and 4 feet broad. It ran nearly horizontally north and south, and consisted of a large chamber and a small passage, both eroded in a master-joint. On the south it contracted to a dead end, now quarried away. Its continuation to the north is obscured by a great accumulation of broken rock and clay, which has not yet been removed. It was filled with a horizontally stratified red clay, containing angular and rolled pebbles of limestone, and a few sandstone pebbles from the Millstone Grit and Yoredale rocks. There were also a few pebbles of white vein-quartz and of quartzite. Scattered through the mass were mammalian bones and teeth, some water-worn and others with sharp fractures. The contents had been clearly introduced into the cave by water, flowing under geographical conditions which no longer exist.

The mammalian remains belong to the following species:—

Machairodus crenatidens, Fabr.
Hyæna, sp.
Mastodon arvernensis, Croiz. & Job.
Elephas meridionalis, Nesli.
Rhinoceros etruscus, Falc.
Equus stenonis, Nesli.
Cervus etueriarum, Croiz. & Job.

All these species are found in the Upper Pliocene deposits of France and Italy, and undoubtedly belong to that age. The *Mastodon*, elephant, rhinoceros, and horse occur also in Britain in the Upper Pliocene deposits of the Crag.

Some of the bones present the characteristic teeth-marks of the hyænas; and the preponderance of the remains of the young over the adult mastodons points to the selection by the hyænas, who could easily master the calves, while they did not as a rule attack the large and formidable adults. The author has observed a similar selection in the case of mammoths in hyæna-dens, into which the remains had been brought by those cave-haunting animals. He therefore concludes that the animal remains have been washed out of a hyæna-den, which then existed at a higher level, and carried down deep into the rock, into the cave in which they were found, along with the clay and pebbles brought down in flood-time from the Yoredale and Millstone Grit hills.

The area of the Victory Quarry must then have been at the bottom of a valley, instead of in its present position on the divide. The denudation of the limestone which has taken place since that time is estimated at not less than 330 feet—an amount sufficient to destroy the ravine formed by the stream above the bone-cave, and all the caves and rock-shelters in the district, which were accessible to the Upper Pliocene mammalia.

The author appends a map illustrating the physical geography of the British Isles in Upper Pliocene time. In it the British area is represented as joined to the Continent by a barrier of land, extending from the Straits of Dover, westward, as far as the 100 fathom line in the Atlantic, which sweeps southward from Scandinavia, off the West of Ireland, into the Bay of Biscay. There were then no physical barriers to forbid the migration of *Machairodus*, *Mastodon*, *Elephas meridionalis*, and the rest, from Central and Southern France into Britain. They could find their way freely from the valleys of the Loire and the Garonne, across the valley now occupied by the English Channel, into England and, it may be added, Ireland. Over this area the animals migrated in the Upper Pliocene age. The discovery of a few of them in Derbyshire is to be looked upon as a monument of their former existence over the whole of this region. It is also a striking example of the great destruction of the surface which has taken place since that time, and of the imperfection of the geological record. It is the only cave in Europe that has yielded remains of the remote Pliocene Epoch.

CORRESPONDENCE.

PTERASPIS IN NORTH CORNWALL.

SIR,—In Dr. H. Woodward's description of *Homalonotus Barratti*, n.sp., in your last number he mentions that I recorded the occurrence of *Pteraspis* at Trevone in a paper which appeared in your MAGAZINE, Dec. IV, Vol. VII, p. 146. This error happened owing to a stupid oversight of my own. I did find a portion of a Ganoid fish in the blue shales of Trevone which was recognized by Dr. Smith Woodward as undoubtedly Devonian, and belonging to a genus not yet described. Specimens of the same form, he said, were in the late Mr. Pengelly's collection. The plate showed the internal structure and the surface was ornamented with small bosses, but he said it was distinct from *Steganodictyum* (*Pteraspis*), Ray Lankester.

In my table showing the Distribution of Fossils on the North Coast of Cornwall, south of the Camel, published in the Transactions of the Royal Geological Society of Cornwall, 1901, vol. xii, part 7, *Pteraspis* is not recorded north of Bedruthan.

Since this table was published I have obtained from Bedruthan a slab on which there are fragments of *Pteroconus mirus*, and another organism of which Dr. Smith Woodward writes: "I think the reticulated piece belongs to *Pteraspis*, but it would have been more satisfactory to find the outer striated layer." HOWARD FOX.

FALMOUTH, *January 5th*, 1903.

THE GEOLOGY OF BARBADOS.

SIR,—My extended acquaintance with the geology of Barbados has led me to concur fully in the last paragraph of the recent article on the subject by Professor Harrison and Mr. Jukes-Browne, and especially in the admission of these authors that "fresh observations are required." For some weeks prior to the appearance of the article, indeed, I had been in correspondence with one of the authors of the article, who proposed a joint re-examination of the ground; I immediately accepted the suggestion, and began planning another trip to Barbados with the object of demonstrating my observations on the ground, and, if practicable, making additional collections of fossils; and I had hoped that public discussion would be withheld pending this appeal to the court of field observation. In view of the prospective meeting on the ground, I am content to withhold detailed criticism of the article in question, and especially of the restricted view taken by the authors, who seem satisfied to discuss the geological history of a single spot in a great province without reference to the records presented by other portions of the same province. I am confident that the joint work on the ground will enable me to present this broader view, as well as the local details, more successfully than I have been able to do in print. "In the meantime" I venture to hope that readers will "suspend their judgment on the questions raised" by the paper of Prof. Harrison and Mr. Jukes-Browne. J. W. SPENCER.

WASHINGTON, *December 19th*, 1902.

CLASSIFICATION OF THE LOWER CHALK OF NORTH GERMANY.

SIR,—There is a curious error in the Short Notice of Dr. A. von Koenen's paper "Ueber die Gliederung der norddeutschen Unteren Kreide" in your December number. The reviewer implies that the result of the learned author's revised classification is to regard the Aptien, Barrêmien, Hauterivien, and Valanginien as subdivisions of the Albien!

We know that the German Albien is sufficiently comprehensive; but it has not yet been stretched to this extent. It is merely that your reviewer, in his innocence, has been misled by finding the Albien standing a little apart in its place at the head of the column of 'stages'! G. W. LAMPLUGH.

14, HUME STREET, DUBLIN.

TELMATOSAURUS, NEW NAME FOR THE DINOSAUR *LIMNOSAURUS*.

SIR,—Professor G. B. Fletcher has had the great kindness to inform me that the name *Limnosaurus*, which I proposed in 1899 for a new

Dinosaurian, was preoccupied by Marsh for a crocodile (1871). I therefore propose to name the Dinosaur mentioned (Nopcsa, Denkschriften R. Akad. Wissensch. Wien, 1899) TELMATOSAURUS.

Baron F. NOPCSA, Jun.

VIENNA, *January* 11*th*, 1903.

GRANITE AND QUARTZ-VEINS.

SIR,—The paper by Mr. J. Lomas on "Quartz Dykes near Foxdale, Isle of Man," which appears in your January number (p. 34), raises an interesting question, and presents the argument in a cogent form. There can be no doubt that, on the fringe of a granite intrusion and in its apophyses, we sometimes find a gradual transition from normal granite, through various rocks which may be termed pegmatite, greisen, etc., to pure vein-quartz. Some phases of this transition are especially well displayed at Foxdale, a locality which I have already cited in this connection (Q.J.G.S., 1895, vol. li, pp. 143, 144), and which has now been described in detail by Mr. Lomas.

Closer inquiry is, however, necessary before we can be warranted in regarding such quartz-veins as igneous rocks in the ordinary sense. There are many indications, both from the geological and from the petrographical side, that the more siliceous products in question, and especially the pure quartz-veins, belong at most to the waning stage of igneous activity, when the temperature had fallen and the agency of water had become a more important factor. Dr. Sorby's well-known researches on fluid cavities, for instance, strongly support this view (Q.J.G.S., 1858, vol. xiv, pp. 471–475). But, further, there is sometimes reason to believe that, in these highly quartzose fringes and veins in very intimate connection with granite, a considerable part of the quartz has replaced felspar, and is therefore not strictly a primary mineral. One very clear example among others was described some years ago by Mr. Marr and myself on the edge of the Shap granite (Q.J.G.S., 1891, vol. xlvii, p. 285). Here distinct pseudomorphs of quartz after felspar put the question beyond doubt. In the greisens of Cornwall and Saxony, the beresite of the Urals, and such peculiar rocks as luxulyanite and trowlesworthite, the occurrence of special 'pneumatolytic' minerals like tin-stone, topaz, tourmaline, and fluor is equally convincing. We must recognize the possibility of a like origin for veins of quartz, or of quartz and mica, even where no direct evidence of replacement is preserved; and the existence of an igneous magma composed of pure, or nearly pure, silica cannot as yet be regarded as proved. ALFRED HARKER.

ST. JOHN'S COLLEGE, CAMBRIDGE.
January 17*th*, 1903.

THE TERM 'HEMERA.'

SIR,—Mr. Jukes-Browne seems to be haunted by the good word 'stratigraphical.' In the January number he finds fault with my table[1] where certain strata are numbered to show their dates with regard to a column of hemera affixed. This he declares makes hemera a stratigraphical unit! Does he mean to say that in an ordinary calendar, when one has "Jan. 15 A B died; Jan. 16 Y Z died," that thereby Jan. 15, 16 become, not time-units, not chronological indicators of the sequence, but the numbers of the tombs wherein the people are buried?

He takes another table, p. 519, "Correlation of Zones and Hemeræ," and says that that shows the hemeræ to be parts of a zone. In a diary one shows the correlation between certain events and certain days of the week. Does that make the days of the week parts of the events? The making of a piece of railway embankment by the deposit of so much earth is set down as occupying Monday and Tuesday; does that make these two days parts of a railway embankment? According to Mr. Jukes-Browne it does. A hemera (that is, Monday) is part of a zone (that is, the railway embankment)—so he says of a geological diary.

Having come to this remarkable conclusion he declares it is my fault that people supposed hemera was used in a stratigraphical sense, in spite of my distinct assertions to the contrary. Now I do begin to see how it is that people use terms incorrectly—they do not test them by expressions of every-day life. But that is their fault, not mine.

S. S. Buckman.

OBITUARY.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., F.G.S.

Born in 1824. Died November, 1902.

By the death of this distinguished geologist, Canada has lost one of her leading men of science. Dr. Selwyn was associated with the Geological Survey of Great Britain from 1845 to 1852. In 1853 he was appointed by the Colonial Office Director of the Geological Survey of Victoria, Australia, a post which he held until 1869, when he retired owing to the Victorian Government refusing to vote the supplies necessary to carry on the work. Returning to England, on the retirement of Sir William Logan, Selwyn was at once appointed Director of the Canadian Geological Survey, a post which he held with distinction from 1869 to 1894, a period of 25 years, when he retired after 48 years of active and varied service, such as few men can lay claim to have seen, in three different and very distant quarters of the globe.

On his retirement he took up his residence in Vancouver, British Columbia, where for the past eight years he had enjoyed a well-earned leisure, dying at the age of 78 years. His life, accompanied by an excellent portrait, appeared in the Geological Magazine for February, 1899 (Dec. IV, Vol. VI, pp. 49–55, Pl. II). (See also *Daily Chronicle*, November 8th, 1902.)

H. W.

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[1] Quart. Journ. Geol. Soc., vol. xlix, facing p. 514.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. III.—MARCH, 1903.

ORIGINAL ARTICLES.

I.—ON SOME FOSSIL PRAWNS FROM THE OSBORNE BEDS OF THE ISLE OF WIGHT.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE V.)

THROUGH the intervention of my friend Mr. William Whitaker, F.R.S., I, some time ago, received from Mr. G. W. Colenutt, F.G.S., of Hanway Lodge, Ryde, Isle of Wight, 26 small slabs of Osborne clay, on which are preserved, in a more or less good state (generally less), a series of prawns and small shrimp-like Crustaceans, collected by him from the Oligocene strata, Chapelcorner Copse, between King's Quay and Wootton Creek, just to the west of the Boat-house, on the shore below Binstead House; also on the shore below Ryde House, and immediately to the south-east of Sea View Pier; where (especially at Chapelcorner Copse) extremely interesting exposures of the Osborne Beds may be seen and studied, between the base of the cliff and low-water mark (see p. 99).

These beds formed the subject of a paper by Mr. Colenutt (see GEOL. MAG., 1888, Dec. III, Vol. V, p. 358); while the small fishes (*Clupea vectensis*) which occur associated with the Crustaceans were described and figured in 1889 by Mr. E. T. Newton, F.R.S., F.G.S., in the Quarterly Journal of the Geological Society (vol. xlv, pp. 112–117, pl. iv).

Since receiving the above specimens from Mr. Colenutt, I have been favoured with three additional examples, also obtained from King's Quay, by Mr. Reginald W. Hooley, of Ashton Lodge, Portswood, Southampton, who has paid considerable attention to the fossils of the Tertiaries of Hampshire and the Isle of Wight.

The entire series comprises fourteen examples of the larger form (see Pl. V, Figs. 1–4) and fifteen of the smaller one (Pl. V, Figs. 5–7), Figs. 1 and 4 of the former having been drawn from Mr. Colenutt's and Figs. 2 and 3 from Mr. R. W. Hooley's cabinet. The smaller form (Figs. 5–7) is from Mr. G. W. Colenutt's Museum.

Owing to the presence of orbicular calcite and some iron pyrites in the clay, it is often very difficult to detect the details of the structure of these Crustaceans; moreover, in order to preserve them from decay, they have to be treated with a coat of hot gelatine, which, although preservative, is apt to obscure minute details of structure afterwards.

PROPALÆMON OSBORNIENSIS, H. Woodw. (Pl. V, Figs. 1–4.)

Although there is no one example of the large Osborne shrimp which has been preserved entire, nevertheless, by a careful examination of the fourteen specimens before me, I am enabled to arrive at a fairly correct notion of the separate parts, and so of the prawn as a whole.

The general outline of its form may be seen from the examples figured on Pl. V, Figs. 1–4, but no restoration has been attempted.

From Fig. 1 we perceive that the carapace measures 20 millimetres in length (the rostrum in this specimen is injured and indistinct, but is better seen in Fig. 2); the depth of the carapace in profile is 11 mm.; the abdomen ('pleonic somites,' Bate) measures 28 mm. in length, minus the telson, which, although wanting in Fig. 1, is supplied by Fig. 3, and is 10 mm. long; the lateral lobes of the tail-fin being about equal in length, or a trifle longer than the telson. In Fig. 2 the rostrum shows five distinct teeth or serrations; a single spine is also to be observed on the hepatic region of the carapace in Figs. 2 and 4; the bifid flagella of the inner antennæ are preserved in Figs. 1 and 2, but the fragmentary remains of the long outer antennæ are only imperfectly seen on some of the slabs; the long slender ambulatory legs measure 25 mm., they are shown in Figs. 2 and 4. But the first and second long and slender chelate limbs are too imperfectly preserved to be made out satisfactorily, though I believe both of them to be present. The abdominal swimming feet (pleopods) are well preserved in Figs. 1 and 2, and are about 12 mm. in length. The pedunculated eye can be seen in Fig. 2 and also in Fig. 4.

In size this prawn closely agrees with the living *Palæmon affinis*, M. Edw.[1] (Pl. V, Fig. 8), but the rostrum in the living form is considerably larger and more strongly serrated, both above and below. The segments of the abdomen (pleon) in the fossil form closely resemble the living genus, but the pleopods are perhaps somewhat longer in the Osborne specimen.

Having regard to the difficulties of dealing strictly with such imperfect material, I venture to define the fossil form as *Propalæmon*, and for a trivial name I have called it after its locality, *Osborniensis*.

PROPALÆMON MINOR, H. Woodw. (Pl. V, Figs. 5–7.)

This little form, of which fifteen examples have been obtained by Mr. Colenutt, from the same beds as have yielded the larger species (*P. Osborniensis*), measures 26 mm. in length (of which the carapace measures 10 mm., the pleon 11 mm., and the telson 5 mm. The

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[1] Fig. 8 is drawn in our Plate of twice the natural size.

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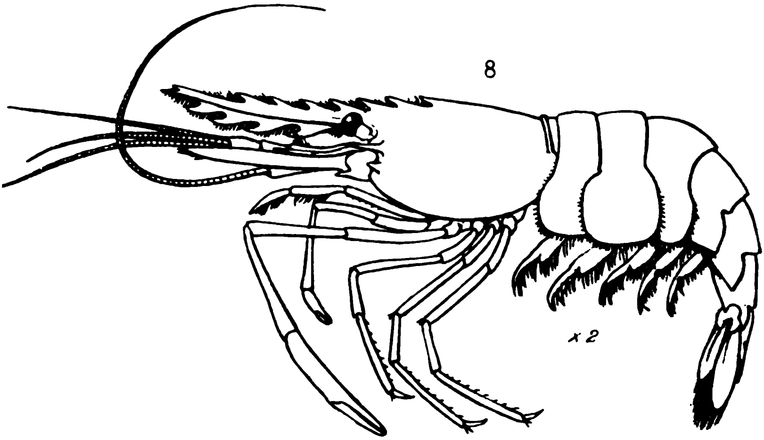

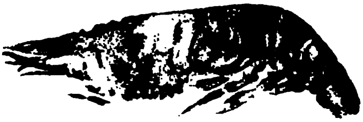

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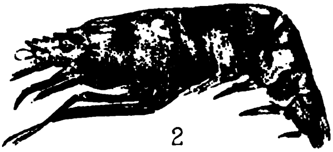

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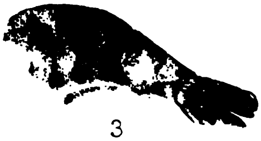

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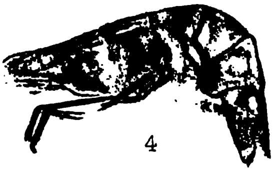

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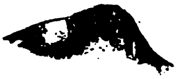

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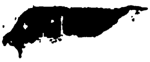

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G M. Woodward del. et lith.

West, Newman imp.

Figs. 1-7. Fossil Prawns &c., Osborne Beds, I. of Wight. $\frac{1}{1}$.
Fig. 8. Palæmon affinis, M. Edw. (recent) $\frac{2}{1}$.

pth of the carapace is 5 mm., and the pleon at the third somite is the same depth. The appendages are not preserved, nor can the rrations on the rostrum be clearly detected.

This may possibly be a young form of the larger species with hich it is found associated, but of that we have no positive ridence before us; it is therefore most convenient to treat it as istinct. Both species occur pretty abundantly in the same bed hich yielded the small *Clupea vectensis*, described by Mr. E. T. ewton, F.R.S., and are in all probability either estuarine or arine. The living Palæmonidæ occur, not only in the sea, but lso in rivers, in Lake Amatitlan Guatemala, the islands of the acific, and one in Australia, *Palæmon affinis*, Pl. V, Fig. 8 (see Voyage of *Challenger*"; Crustacea, by C. Spence Bate, 1888, ol. xxiv, p. 782, pl. cxxviii, fig. 5). Two genera are British.

In this genus (*Palæmon*) the most striking feature is the elongtion of the second legs in the male, which not infrequently even xceed the total length of the animal's body; a specimen of *Palæmon* r may measure about five inches from the front margin of the arapace to the tip of the telson, and carry limbs eight inches long. See "A History of Crustacea," by Rev. T. R. R. Stebbing, F.R.S., p. 246–247.)

The following account (Art. II) of the geology of a portion of he Osborne Beds of the Isle of Wight, whence the fossil Crustacea vere obtained, has been most obligingly drawn up for me by Ir. G. W. Colenutt, F.G.S., the first discoverer of the fossils.

EXPLANATION OF PLATE V.

IGS. 1–4.—*Propalæmon Osborniensis*, H. Woodw. Osborne Beds: Isle of Wight.
IGS. 5–7.—*Propalæmon minor*, H. Woodw. Osborne Beds: Isle of Wight.
IG. 8.—*Palæmon affinis*, M. Edw. Recent: Port Jackson, Sydney, New South Wales.

II.—Note on the Geology of the Osborne Beds.[1]

By G. W. Colenutt, F.G.S.

THE fossil shrimps or prawns briefly described in the preceding paper by Dr. H. Woodward occur in the 'fish-clay' of the sborne Series at Chapelcorner Copse, Binstead House, Ryde House, nd Sea View, Isle of Wight, and they were first discovered by me in hese beds about the year 1876. Having regard to the fact that ew species of fish, etc., have been recently obtained from the sborne Beds, it would seem that these prawns are very probably lso new to English strata.

At nearly all outcrops of these beds the strata yield few fossils, but there are some eight or ten feet (vertical measurement) of strata at the base of the upper division of the series (the St. Helen's Sands of Forbes) which are rich in fossils in some localities. In consequence of the soft nature of the clays, retaining or sea walls have been built nearly all the way from Ryde to Sea View, and, unfortunately, as it is here found, generally speaking, a short distance above or about high-water mark the fossiliferous band is obscured by the walls, the outcrop, roughly speaking, being about horizontal between the two places. Only four localities where these beds can be examined are at present known, namely, at Sea View (here often covered up by sand and shingle), at Ryde House (now mostly obscured by an old 'founder' of the low cliff), at Binstead House (an imperfect exposure), and at Chapelcorner Copse, just west of Wootton Creek. This last is by far the best section, and we will take it as representing the others.

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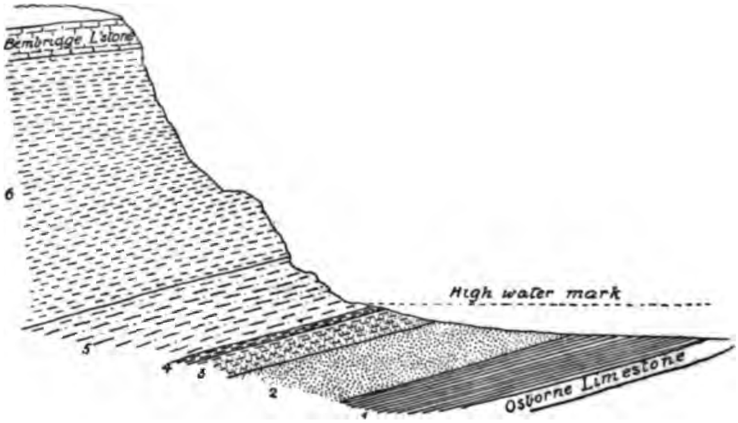
[1] The following is a list of the papers bearing on the present article:—

G. W. Colenutt, "On the Osborne Beds": Geol. Mag., 1888, p. 358.
E. T. Newton, "On *Clupea vectensis*": Q.J.G.S., February, 1889, vol. xliv, pp. 112–117, pl. iv.
E. T. Newton, "Geology of the Isle of Wight": Memoirs of Geological Survey, 1889, p. 152 et seq.
E. T. Newton, "On *Amia*": Q.J.G.S., February, 1899, vol. lv, pp. 1–10, pl. i.
G. W. Colenutt, "Notes on Geology of the North-East Coast of Isle of Wight": Papers and Proceedings of the Hampshire Field Club for 1891.

The ledge of rocks just above low-water mark is the limestone of the Osborne Series, forming the topmost division of the 'Nettlestone Grits' of Forbes; and tracing the strata in ascending order from this base we have the following series of beds:—



Section showing the succession of the Osborne Series from the Osborne Limestone at the base to the Bembridge Limestone at the top. (Fig. 4 of this section is the bed which has yielded the small *Clupea vectensis* and the Crustaceans described by Dr. H. Woodward.)

Vertical Estimated Measurements.

1. (Bed 6 in my paper, Geol. Mag., 1888, p. 359.) Dense clay, green and brown mottled, about 4 feet; no fossils whatever, as far as I am aware.

2. (Bed 5 in my paper, op. cit.) A series of clays of fluviatile origin, about 6 feet. At the base is a dark blue or blackish seam, about 2 inches thick, of finely comminuted shells mixed with carbonaceous clayey particles. This seam has yielded bones of *Trionyx*, teeth, etc., of *Alligator Hantoniensis*, bones of *Amia Anglica* (*vide* Mr. Newton's paper), also the jaw of *Amia Colenutti*, scales of

Lepidosteus, many small fish-bones, vertebræ, etc.; and in this seam I have also noticed small dark blue or green pebbles, apparently of flint. The shells are probably *Paludina lenta* and *Melanopsis carinata*, but are almost too crushed to be identified. There is above this most interesting seam about three feet of rather hard stratified dark blue clay, with many seams of *P. lenta* and *M. carinata*, mostly crushed, but some perfect, with occasional masses of iron pyrites encrusting the shells, and also some lenticular masses of grey cement-stone.

3. (Bed 4 in my paper, op. cit.) The clay slightly alters, fewer seams of shells being observed, but at the top of this division, which may be about 3 feet thick, we find many vegetable remains matted together. These are mostly of reeds or sedges, but are not yet identified; occasionally one may find carbonized seed-vessels resembling *Folliculites thalictroides*, but somewhat different in shape; also some much smaller oval seeds; flat leaves of reeds or water plants with roots and rootlets attached, somewhat resembling the living *Zostera*, occur abundantly. All these plant remains are associated with *Paludina* and *Melanopsis*, and are in layers in a somewhat soft grey clay; it is difficult to preserve the plants, as they crack and curl up on drying. Lenticular masses of cement-stone also occur in this division.

4. (Bed 3 in my paper, op. cit.) Immediately above the plant bed occurs the 'fish-clay.' This is a seam of dense, dark greenish grey clay about 7 inches thick, very distinct in character from any of the other clays. It acquires a lighter colour on drying, and when dry assumes a somewhat granulated surface. It is a continuous seam, judging from its appearance at the several sections. It has not been found west of King's Quay, nor is it seen at Whitecliff Bay. The clay has an irregular transverse jointing, and readily separates into rough nodules. It is highly laminated, and easily flakes when split with the point of a knife; it is about as hard as ordinary yellow soap. It is much charged with iron pyrites, in the form of dark gritty masses or lumps in the clay. *Clupea vectensis* and the prawns are found distributed in this seam; the top half-inch of the bed is the best place, however, in which to look for them. The fish are generally in small shoals, but the prawns are usually solitary, though the smaller ones do occur in shoals. No insect remains have as yet been observed.

5. (Bed 2 in my paper, op. cit.) Above the fish bed are several feet of green, brown, and grey clays, of a flaky nature, and on one horizon thin lenticular masses of fish bones, etc., occur. These deposits have yielded remains of *Lepidosteus* (vertebræ, scales, and bones), snake vertebræ, jaws and vertebræ of *Amia Anglica*, teeth of *Theridomys*, *Palæotherium*, *A. Hantoniensis*, bones of *Emys* and *Trionyx*, and quantities of bones and vertebræ of teleostean fish, etc. These are obtained, of course, by drying, scalding, and washing the clay.

6. (Bed 1 in my paper, op. cit.) Above this is about 40 feet or so of the usual mottled unfossiliferous green, red, brown, grey, and

yellow clays of the Osborne Series, capped at the top of the cliff by the Bembridge Limestone.

Judging from the character of the fossils, we seem to be justified in coming to the conclusion that Nos. 1, 2, and 3 were deposited in an estuary, or in a lake, or lagoon near the sea; the mollusca are fluviatile, and so are the vertebrate remains. At the top of No. 3 we have evidences of much plant growth, pointing to a calm lagoon, in which deposition was slow and regular. The fish-clay is puzzling, and we shall probably not be far wrong in assuming that a sudden influx of marine mud caused its deposition. The *Clupea* are most probably marine forms, and all the fish appear to have been smothered or asphyxiated, as the jaws are wide open and the fish are quite perfect. It remains to be seen whether the prawns are marine or fluviatile forms. Above the fish-clay we find that the *Paludinæ*, etc., disappear, pointing to much more brackish conditions; the lenticular masses of bones suggest drifting and the influence of deeper water, while further up the mottled red clays decidedly indicate semi-marine conditions of deposition.

In a local series like the Osborne Beds it is not surprising that new forms should be found, especially in a deposit which varies so much in its different outcrops.

III.—EOLITHS FROM SOUTH AND SOUTH-WEST ENGLAND.

By the Rev. R. ASHINGTON BULLEN, B.A. Lond., F.G.S.

(PLATES VI, VII, AND VIII.)

I. Introduction.
II. Character of the Eoliths.
III. Researches of Blackmore, Westlake, and C. Reid.
IV. Eolithic Localities in the Drainage Area of the Avon.
V. The Dewlish Implements.
VI. Use of Hollow 'Scrapers.'
VII. Description of Specimens figured.
VIII. Bibliography.

I. *Introduction.*

THE labours of Mr. Benjamin Harrison around Ightham, in Kent, have been before the scientific world since May, 1889, when Sir Joseph Prestwich read his now historic paper before the Geological Society "On the occurrence of Palæolithic Flint Implements in the neighbourhood of Ightham, Kent; their distribution and probable age."

This was followed in 1891 by an even more important one, "On the Drift Series of the Valley of the Darent, with remarks on the Palæolithic Implements of the district, etc.," also read before the Geological Society.[1] In this masterly memoir he gave the results of his long and careful examination of, more particularly, Mr. B. Harrison's collection of flint implements from the neighbourhood of Ightham, their distribution and probable age.

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[1] Published in the Quart. Journ. Geol Soc., 1891, vol. xlvii, pp. 126–163.

On the gravelly soils, and in the gravels of certain areas of the Chalk Plateau above Ightham, have been found some deeply stained implements, of either the same kind as those of St. Acheul or those of Chelles in France, "for the most part of oval or ovate forms, but not unfrequently pointed."[1]

M. Mortillet regarded this gravel at Chelles as a high-level river-drift, equal to the oldest of St. Acheul (see also C. H. Read's "Guide to the Antiquities of the Stone Age," British Museum, 1902, p. 9). It may be noticed that two of these ovoidal implements from the Chalk Plateau are figured by Professor Prestwich in his "Controverted Questions, etc.," 1895, pl. xi, figs. 38 and 39, which are referred to by him as being of the St. Acheul type, but either shaped by the same people that made the plateau specimens, by individual progress in the art of shaping tools, or probably by some later valley folk passing over the hills and dropping their weapons and tools (p. 64).[2]

Associated with these implements there occur very abundantly on the Chalk Plateau, as carefully exploited by Mr. B. Harrison, other flints of definite shapes, and deeply coloured, known as 'eoliths' and 'old brownies,' which have been subject to much diversity of opinion among some, especially inexperienced observers. In certain localities, these probably earlier implements occur without being associated with the large ovate forms.

II. *Character of the Eoliths.*

The general features of the eoliths,[3] as we shall continue to designate these ruder and earlier forms, are well marked and distinct.

They are made of flint flakes (sometimes tabular), probably broken off by natural forces, but some are formed of split Eocene pebbles. They rarely show the bulb of percussion. Advantage has been taken by the original worker of natural curves, concave or convex, and these have been modified by well-defined small flakings. In some cases smaller flakes have modified these; in many instances the edges have been further modified by local pressure being used (which we may distinguish as *abrasion*), or in other cases the edge has been rubbed and rounded by *contusion* with other flints in the ordinary course of trituration or wearing away by rolling in a river bed, or in a rough downward passage from higher to lower ground.

The edges of many of the eoliths discovered by Dr. Blackmore in Wiltshire are quite sharp, and cannot have travelled far. I have also one from Hinton Admiral Common, Hants, and another from

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[1] Evans: "Ancient Stone Implements," 1897, 2nd ed., p. 608.

[2] I have in my collection one such deeply stained ochreous specimen from Currie Farm, Kent (fig. 6 of pl. xxi, Prestwich, "Primitive Characters, etc.," p. 246). Two others, one ovate (St. Acheul type), and the other (referred to by Prestwich, "Drift Stages, etc.," p. 133) of the sharp-pointed high-level type, with massive butt (tip broken off), are both white and patinated, and are the implements referred to in the text.

[3] They have been termed 'plateauliths' by Mr. Lewis Abbott.

Well Hill, Kent,[1] whose edges are almost or quite free from contusion.

We are now in a better position thus to define the eoliths through Dr. H. P. Blackmore's work at Alderbury during many years. In that deposit at 325 feet O.D., about 3 miles south-east of Salisbury, no palæoliths of accepted type have been discovered, a fact which demonstrates to my mind the later age of some of the more or less ochreous implements of Palæolithic types from the Chalk Plateau of Kent. Thus the Pre-Glacial plateau specimens are divisible into two periods, although Prestwich in his two papers classed them all as palæoliths, and in Professor Rupert Jones' opinion this mixture of early Palæolithic and Eolithic types only shows that man varied his work.

Some Palæolithic implements from the Kent plateau with a porcellaneous lustre have also occurred as surface finds near Bower Lane, Eynesford. These belong to a later epoch, and seem to have been dropped by Palæolithic hunters on the surface and to have been bleached by contact with the clay. The alumina of the clay undoubtedly has this bleaching action, and even softens the flints by extracting the water of crystallization, either as they rested or were slightly embedded in it.[2] This also seems to have been the case of Prestwich's porcellaneous Downton implement quoted by Mr. C. Reid, which occurred at a level to which in age it does not apparently belong.[3] However, the fact remains that from the gravel deposit at Bat's Corner, Kent (the British Association pit excavated by Mr. B. Harrison, 1894, the geological age of which is somewhat uncertain, but probably pre-Glacial), and from the pit at Alderbury worked so assiduously by Dr. H. P. Blackmore (the age of which, from the occurrence of *Pecten asper* and other Gault and Upper Greensand fossils, is that of the Southern Drift), the implements of Palæolithic type are wanting, and the Eoliths wrought and used by man only occur. These are either 'straight sleekers,' 'round sleekers,' or 'hollow scrapers,' certain of them with the point somewhat like a bird's beak, which characteristic form Dr. Blackmore considers especially belongs to implements of the Eolithic epoch.

As this bird-beak point occurs in not a few definite palæoliths (Dr. Blackmore has several in the Museum at Salisbury), and the hollow curve in not a few others (the latter notably in those from the newly discovered Knowle Pit, Savernake), we seem to be arriving at some steps in the evolution of the palæolith.

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[1] This specimen, found close to the 500 feet contour, may have been made near the spot where found. Professor Rupert Jones, however, from the point of view of the denudation of the Weald, suggests that implements belonging to the Southern Drift, moving downward along the slopes of the Old Wealden Heights, and enclosed in mud or clay, might travel a considerable distance without being subject to contusion.

[2] Bullen, "Eolithic Implements": Trans. Victoria Institute, 1901, vol. xxxiii, p. 196.

[3] "Geol. of Country round Ringwood," p. 36. The specimen is preserved in the Prestwich Collection in the Geological Gallery of the British Museum (Natural History), in the tenth drawer, left-hand tier.

III. *Researches of Messrs. Blackmore, E. Westlake, and Clement Reid.*

Mr. E. Westlake, F.G.S., is now in the rank of workers on the Eolithic question, and both he and Dr. Blackmore have kindly placed their records from the Plateau terraces (or 'plains') of the Ringwood area at my service in writing this paper. With two such trained and enthusiastic workers on the spot our knowledge ought to advance rapidly.

From 1898, when Dr. Blackmore found an eolith in gravel on the ridge at Woodfalls, near Redlynch, to the present year,[1] a sufficient number of eoliths have been found by both the two above-named workers to constitute the Plateau gravels of the Ringwood district effective witnesses for the existence of man at a less advanced stage of progress as to the manufacture of stone implements—lower, i.e., than in the next or Palæolithic stages of human culture. For these Plateau gravels are the highest in the New Forest district.

Mr. Westlake states :[2] "On November 4th, 1902, I found several examples of eoliths in the east pit on Black Bush Plain, at a height of about 410 feet O.D., or 310 feet above the Avon at Breamore. This gravel caps the highest ground between Fordingbridge and Southampton ; and, beyond having a slight slope towards the Solent, has no obvious relation with any of the surrounding valleys. The flatness of the plain and the much rolled and battered character of the gravel, I think, point more to the marine origin suggested by Mr. Codrington (1870) than to the river origin suggested by Mr. Reid (1902). . . . . There can be no question as to the position and antiquity of the gravel."

Mr. Clement Reid has seemingly good reason for his reference to river action, at least in contributing materials for the gravels, in the fact that Jurassic rocks (silicified Purbeck Limestone) occur in the Plateau gravels at 386 feet O.D. near Picket Corner.[3]

As the present paper, however, is rather simple in its scope, the intention being to put on record the occurrence of Eoliths among the Plateau gravels, we leave the existence or not of a Solent river to the evidences for which, *pro* and *con.*, Mr. Reid refers[4] in a useful footnote. He is to be congratulated on breaking free from the usual prejudice and tradition about man's geological age, and on accepting and incorporating, in a memoir issued by the Geological Survey, the long-despised and suspected Eolith.

But in one small particular the "Diagram of the Terraces of the Avon" (fig. 4, p. 34, op. cit.) needs reorganizing, for the researches and 'finds' of Dr. H. P. Blackmore (1898–1902), of Mr. E. Westlake

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[1] The writer had previously found hollow curved scrapers at the summit of Alum Chine and on Hinton Admiral Common in May, 1895, and a derived specimen at Jumper's Heath in November, 1893. These were shown to and approved by the late Sir Joseph Prestwich in 1893 and 1895 respectively.

[2] "Antiquity of Man in Hampshire," last page. King's Fordingbridge Almanac, 1903. An eolith from White Shoot Farm is figured in the text.

[3] C. Reid: "Geol. of Country round Ringwood," p. 30.

[4] Op. cit., p. 32, note.

(1902), and of myself (1895) establish the Eolith in the proud position of occupying the high plateau above the 400 feet contour, or its equivalent further to the south. (See Sheets 314, 329, Geol. Survey, new 1 inch map, printed in colours.)

IV. *Eolithic Localities in the Drainage Area of the Avon.*

The under-mentioned localities are those represented in the collections particularized:—

I. Dr. H. P. Blackmore, F.G.S.[1]

		Height above O.D. feet.
1.	Tinney Copse ... ... (This is the White Shoot Pit of Westlake, *infra.*)	375
2.	Deadman Hill Pit, locally known as Alderton	360
3.	Hale's Purlieu	365
4.	Hatchett's Green	345

II. Mr. E. Westlake, F.G.S.[2]

			Approximate height above O.D. feet.		Approximate height above Avon. feet.
	1.	Piper's Weight,[3] about one mile north of the last pit (locally 'Long Cross' Pit) on Black Bush Plain	421	...	321
Plains.	2.	Black Bush Plain	400	...	300
	3.	Turf Hill Pit, south of the Downton Road, about one mile north-west of the Telegraph (= old Semaphore) ...	380	...	280
	4.	White Shoot Pit, one mile south of Redlynch	375	...	265
	5.	Godshill Ridge Pit, marked on the 6 in. map as Gravel Pit Hill	325	...	235
	6.	The eastern pit on Frogham Hill, locally known as Abbot's Well Pit...	260	...	180
	7.	Bournemouth : Alum Chine, fallen gravel from top of cliff	120	...	—
Palæolithic.[4]					
Early Palæolithic.					
		Hyde Common Pit	230	...	150
		Sandy Balls Pit...	240	...	150
Middle Palæolithic.					
		Woodgreen Pit	200	...	100

It is noteworthy that all the Eolithic localities examined, both by Dr. Blackmore and Mr. Westlake, occur at a higher level than the second terrace, 300 feet O.D. (the Eolithic), in Mr. Clement Reid's diagram of the Terraces of the Avon,[5] and that the other localities at Alum Chine and Hinton Admiral Common are on the high plateau further south, though at a less elevation O.D. because of the southward slope of the plains.

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[1] Blackmore, in letter.

[2] Westlake, in letter.

[3] This is the highest point in the New Forest.

[4] These lower terraces seem to correspond to those so successfully worked by Mr. S. Hazzledine Warren, F.G.S., in the Isle of Wight (Geol. Mag., Sept. 1900, pp. 406–410). They are inserted here merely to contrast the well-defined terraces yielding accepted Palæolithic forms and the higher Eolithic terraces.

[5] Geol. of Country round Ringwood, p. 34.

V. *Criticism of Mr. Clement Reid's statement about the Dewlish Eoliths.*

In concluding this short notice I regretfully animadvert on Mr. Reid's statement[1] that the flints associated with *E. meridionalis* at Dewlish are so battered that their artificial origin is open to much doubt. The only specimen for which this statement could possibly stand is the one numbered 15*f* (Bullen, "Eolithic Implements," pl. iii, fig. 2). The others, Nos. 28, 18, 32, 31*f* (Dr. Blackmore's collection), have much less 'batter' than usual upon their well-defined edges, which circumstance, to those accustomed to discriminate between natural and artificial flaking and chipping, is of most persuasive force. The above-mentioned stone tools are before me as I write. Their colour, originally deeply ochreous, has been lightened very considerably by bleaching in the sandy matrix in which they had so long lain.

VI. *Use of Hollow 'Scrapers.'*

A passage in Sir J. W. Dawson's "Modern Science in Bible Lands," p. 300, deserves quotation in its entirety, as it may throw light on some, if not the majority, of the hollow 'scrapers' so characteristic of Eolithic workmanship, especially when we consider the prime necessity to man of procuring fire in all stages of his civilization :—"When in Egypt in 1844 I saw women in the market at Assiout with baskets of flint flakes on sale. I asked the use of these, and found they were for strike-lights. I asked, 'Why do they not use matches?' The answer was, 'Matches are too dear for the fellaheen. It is much cheaper to have a flint and steel, and a little fibre from the spathe of the doum-palm to light their cigarettes.' I afterwards verified this by examining the tobacco-pouches of some of the people, and exchanged with one of them a new flint for one that he had used so long that its front had been chipped into a semicircular form, like that of one of those hollow scrapers one sees in collections of stone implements, and which are supposed to have been used for polishing shafts of spears, but some of which are possibly worn-out strike-lights of dubious antiquity. It may be observed here that in the most primitive times, before steel could be obtained, the native[2] iron pyrite was used for the same purpose, as evidenced by fragments of it found in very ancient burial-places and caverns of residence."

Iron pyrites, however, is not absolutely necessary for the procuring of fire; the percussion of quartz and flint[3] produces sparks, and probably the percussion of flint or chert with flint[4] would do so, since they are all forms of silica, either crystalline or amorphous.

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[1] Ibid., p. 36.

[2] Joly: "Man before Metals," 3rd ed., p. 196.

[3] Jago, Royal Cornwall Gazette, Nov. 29, 1900: Royal Institution of Cornwall Annual Meeting. Mr. A. Pott (of Bath) writes, "I find I can get finer sparks from the quartz and flint than from either with the pyrites."

[4] An illustration of how strike-a-lights of flint, found in the Dordogne Caves, may have been used is given in the *Reliquiæ Aquitanicæ*, Feb. 1870, pt. x, pp. 138, 139, figs. 36, 37.

VII. *Description of Plates.*

PLATE VI.

FIG. 1.—Double-shoulder scraper, work on one face only; sub-ochreous, rather bleached, probably by vegetable action.[1] Deadman Hill, 400 feet O.D. (H.P.B.)

FIG. 2.—Similar implement from Alderbury, split pebble with drusic cavity on reverse, slightly ochreous. Alderbury, 325 feet O.D. (H. P. B.)

FIG. 3.—Bleached, frost-bitten, double-shoulder scraper, showing greatest use on curve of left shoulder; right shoulder produced by removal of a single flake. Sharp edges of each curve removed by local abrasion due to use. Near Tinney Copse, about 375 feet O.D. (H. P. B.)

FIG. 4.—Hollow curve of Upper Greensand chert, having no signs of human use. Hale's Purlieu, about 365 feet O.D. Source: Vale of Wardour. (C. Reid, op. cit., p. 30.)

FIG. 5.—Rough flake from a 'Woolwich and Reading' pebble made into a hollow 'scraper'; edge still acute, resembling others from Alderbury; sub-ochreous; bleached probably by vegetable action. Hinton Admiral Common, 110 feet O.D. May 28th, 1895. (R. A. B.)

FIG. 6.—Bleached hollow 'scraper' just below summit of Alum Chine, much more rolled than Fig. 5. Alum Chine, about 110 feet O.D. May, 1895. (R. A. B.)

PLATE VII.

FIG. 1.—Ochreous, hollow, beaked 'scraper' from Alderbury; edges of curve sub-acute. Alderbury, 325 feet O.D. (H. P. B.)

FIG. 2.—Ochreous, hollow, beaked 'scraper,' sub-acute, blunted by local abrasion through use, or contused by natural causes. Near Tinney Copse, about 375 feet O.D. (H. P. B.)

FIG. 3.—Sub-ochreous, hollow 'scraper,' frost-bitten, sub-acute, with a convexo-concave surface showing work on both faces. Deadman Hill, about 360 feet O.D. (H. P. B.)

FIG. 4.—Massive hollow 'scraper,' bleached by contact with clay or loam. Porcellaneous on worked curve and other parts; the high patina probably caused by the scouring of water containing sand or silt. Near Tinney Copse, about 375 feet O.D. (H. P. B.)

FIG. 5.—Hollow 'scraper' with well-defined symmetric curve, showing primary and secondary chipping and local abrasion from use, the latter modifying the sharp edge produced by the smaller secondary chipping. Deeply ochreous, older than the valley gravels with which it was associated. Jumper's Heath, about 20 feet O.D. (R. A. B.)

MAP, PLATE VIII.

Incidentally one is inclined to discount the value of mineralogical condition, at all events in determining the age of Eolithic implements. Taking the hollow scrapers as an example, though of the same type, these show, even from the same deposit, e.g. Alderbury, great differences as regards stain, hardness, patina, and wear.

In conclusion I would thank Dr. Blackmore and Mr. Westlake for their kind co-operation, and Professor T. Rupert Jones, F.R.S., for helping me both in the manuscript and the proofs.

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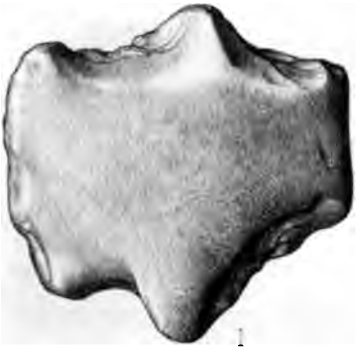
[1] For rationale of this bleaching of flints, see Codrington on the superficial deposits of the South of Hampshire and the Isle of Wight: Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 528.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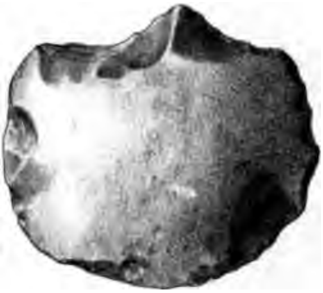
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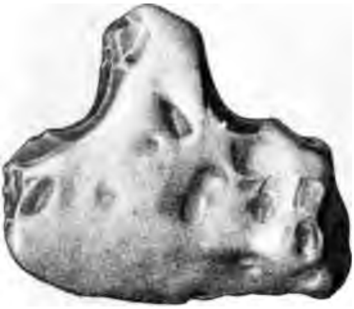
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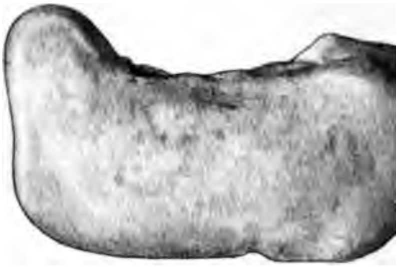
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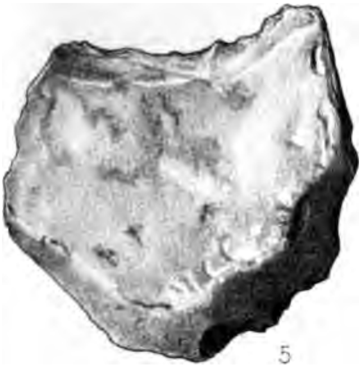
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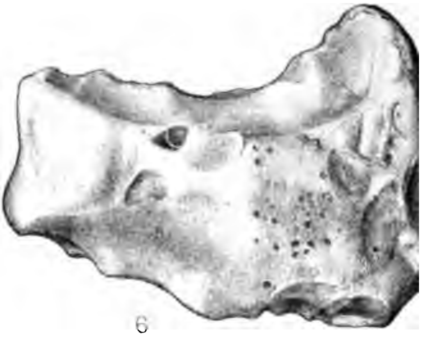
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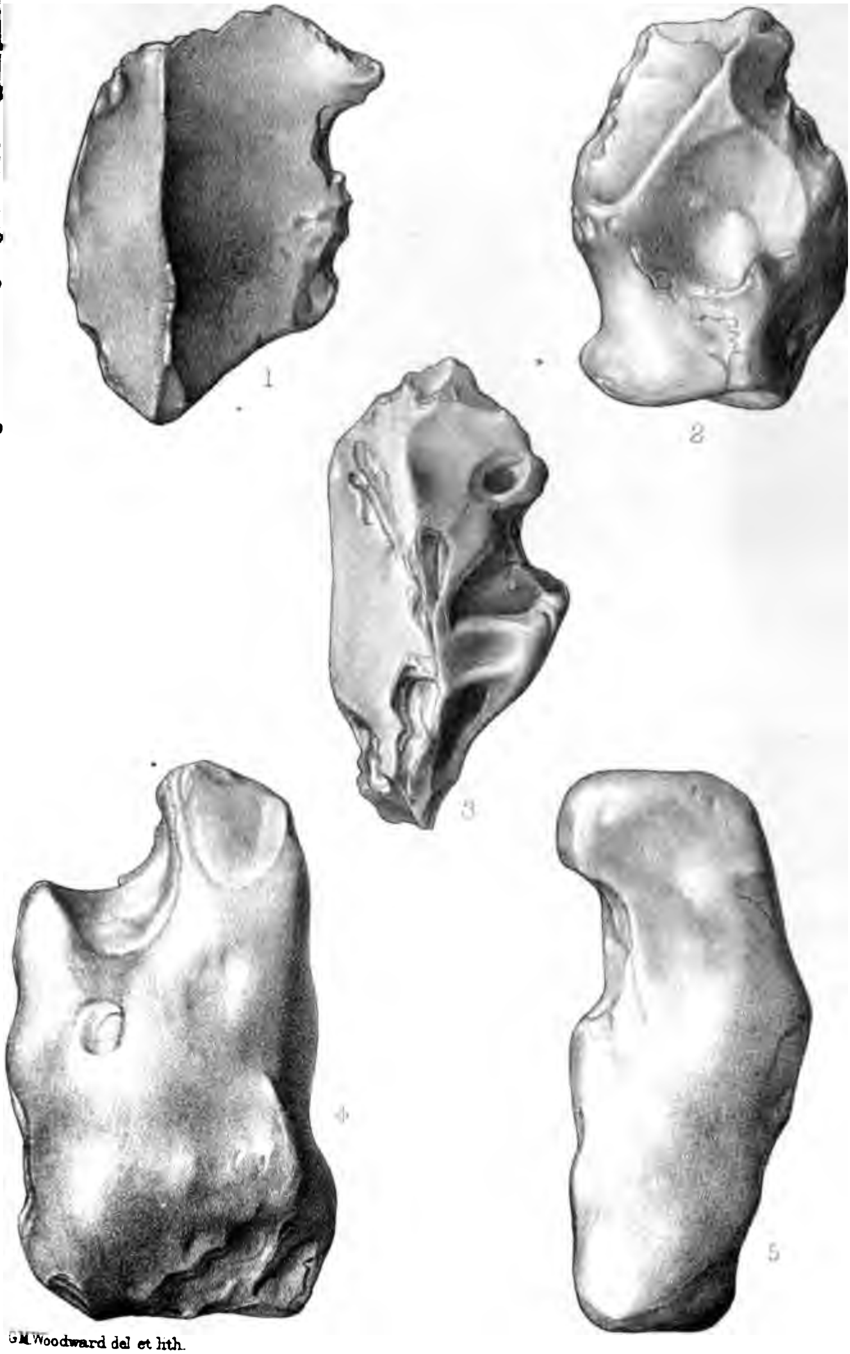
G. M. Woodward del. et lith.

West, Newma

Eoliths, *from S. W. Hants.* $\frac{3}{4}$ *nat. size.*



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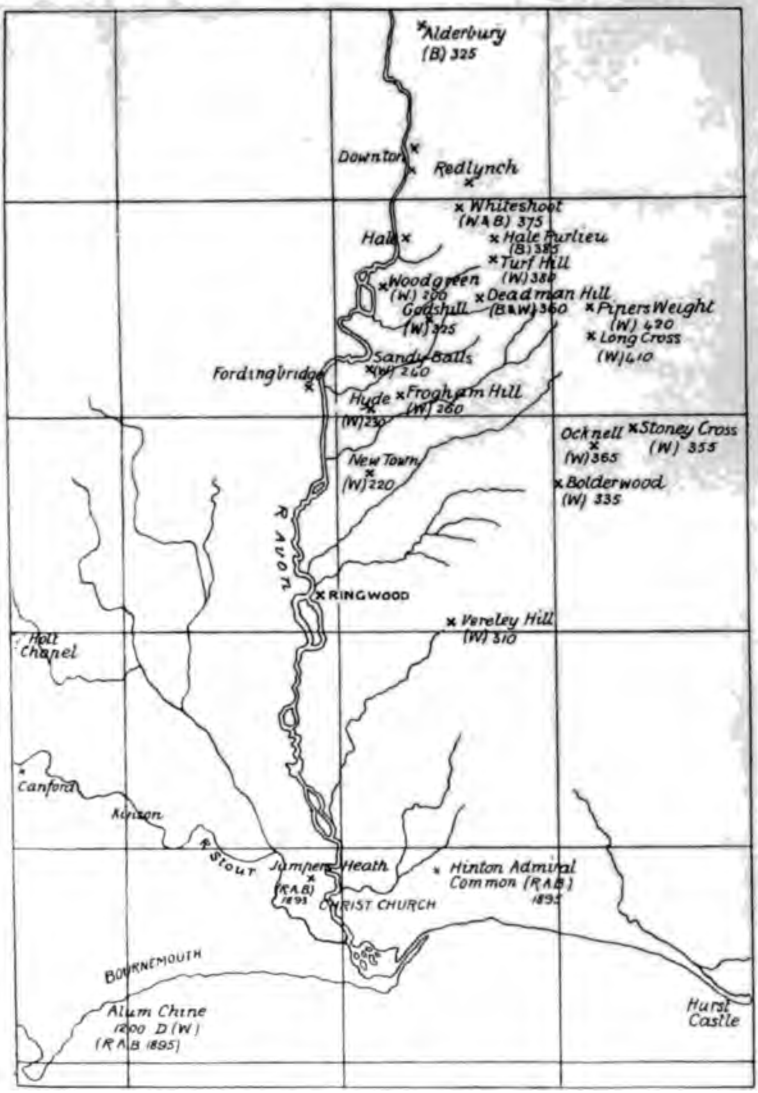
West, Newman i

Eoliths. from S. W. Hants. $\frac{3}{4}$ nat size.



R. Ashington Bullen.

oliths from the Plateau-Gravels of South-West Hants, near Ringwoo

Map showing the course of the Avon below Downton.

W., Westlake; *B.*, Blackmore; *R.A.B.*, Bullen. The squares are each five miles.

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IV.—ON SOME REMAINS OF A GIGANTIC FOSSIL CIRRIPEDE FROM THE TERTIARY ROCKS OF NEW ZEALAND.

By W. Blaxland Benham, D.Sc. (Lond.), M.A. (Oxon), F.Z.S.,
Professor of Biology in the University of Otago, N.Z.

(PLATES IX AND X.)

In the course of conversation with Professor J. Park, the Director of our School of Mines, I first heard of the occurrence of a gigantic pedunculated Cirripede in certain Tertiary deposits on the east coast of the North Island of this colony. I then wrote to

Mr. T. F. Cheeseman, the Curator of the Auckland Museum, in which some remains were exhibited: in answer to my request, Mr. Cheeseman very generously loaned me these remains, and the following notes are founded on them. I will here express my thanks to this gentleman for the readiness with which he has, in this and other instances, complied with my request for the loan of specimens out of his museum. But these few fragments do not represent all that is known of the animal; for I understand that abundant material, collected by Professor Park during his geological survey, is entombed in boxes in the Colonial Museum at Wellington, and Professor Thomas, of Auckland, also possesses, as he informs me, a fair supply of valves, collected by himself.

I have, however, not been able to examine either of these collections. And although the present contribution is very incomplete, yet I hope that it will stimulate the possessors of better material to supplement or correct my remarks; at any rate, it will serve to direct the attention of European geologists and zoologists to the existence in late geologic times of a Cirripede remarkable chiefly for its gigantic size, far surpassing any member of the group hitherto known to science.

Portions of this fossil were exhibited in 1887 by Sir James Hector at a meeting of the Wellington Philosophical Institute, when he made the following remarks :—[1]

"The large fossil Cirripede collected by James Park will probably be found to belong to the genus *Scalpellum*, and is distinguished provisionally under the name *Sc. Aucklandicum.* In size this fossil Cirripede exceeds greatly any previously known; in *S. magnum* the capitulum being 1½ inches in length, while in the Auckland specimen it is at least 8 inches.

"The fossil occurs in a breccia marking an old shore-line of the upper part of the Waitemata series, similar to the Cape Rodney beds. The associated fossils are corals, brachiopods, and echinoderms. Among the latter are two specimens of *Cidaris* having plates of enormous size."

These fossils were collected on the island of Motutapu, in Auckland harbour. Park[2] states that "the island consists of Tertiary sandstone and clays on a highly denuded surface of slates, sandstones, and schists, of probably Palæozoic age."

According to Sir James Hector, the Waitemata series belong to his 'Cretaceo-Tertiary' system, whereas Captain Hutton regards it as Miocene.[3]

Sir James Hector, as above stated, attributed the fossil to the genus *Scalpellum*, and proposed the name *Sc. Aucklandicum*, without, however, further describing it.

But, I think, a careful comparison of the scutum and carina with the fossil valves described by Darwin indicates a closer resemblance to certain species of *Pollicipes*; nevertheless, I do not think I am justified in transferring it to this genus till a greater number of valves have been studied, especially in consideration of the difficulties, pointed out by Darwin, of distinguishing the two genera from the valves only; and it must be borne in mind that the criteria put forward by him are not applicable to the living forms, for he expressly limited them to fossil representatives.

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[1] Trans. N.Z. Institute, vol. xx, p. 440.

[2] Geological Reports (N.Z. Government), 1887, p. 225.

[3] Hutton: Trans. N.Z. Institute, vol. xxxii, p. 171.

The only character referred to by Sir J. Hector is the great size of the fossil; and certainly this is, as it happens, a sufficient diagnosis of the species. The largest capitulum known amongst living species of *Scalpellum* is that of *Sc. Darwinii*, Hoek, which attains a length of 46 mm. (nearly 2 inches); and only a few other species approach this size, viz., *Sc. eximium*, Hoek, 43 mm.; *Sc. gigas*, Hoek, 40 mm.; and an undescribed species in my possession from the coast of this island is of the same length as the last. Amongst fossil forms, the largest capitulum recorded by Darwin is 1½ inches (about 37 mm.) in length, and only two entire capitula reached this size, viz., *Sc. magnum* and *Sc. maximum*.

Turning to *Pollicipes*, all the known species are of small size; existing forms are less than 1 inch (25 mm.), and the only entire capitulum described by Darwin was ½ inch (say 13 mm.) in length.

It will be seen, then, that the capitulum of the species of which certain valves are described in the present article was of extraordinary size; it must have attained the enormous length of nearly a foot (300 mm.), and possibly more; for the tergum would, by analogy with other elongated species, project considerably beyond the scutum, while the inferior valves would still further add to the length.

The material at my disposal includes four recognizably identifiable valves, with some fragments insufficiently complete to describe, though one amongst the latter is, I believe, a portion of one of the lower series of the capitulum, probably the 'carinal latus.'

The four recognizable valves are—

(*a*) The *carina*.
(*b*) The *scutum* of the left side.
(*c*) The *rostrum* (?).
(*d*) One of the lower whorl (? the 'upper latus').

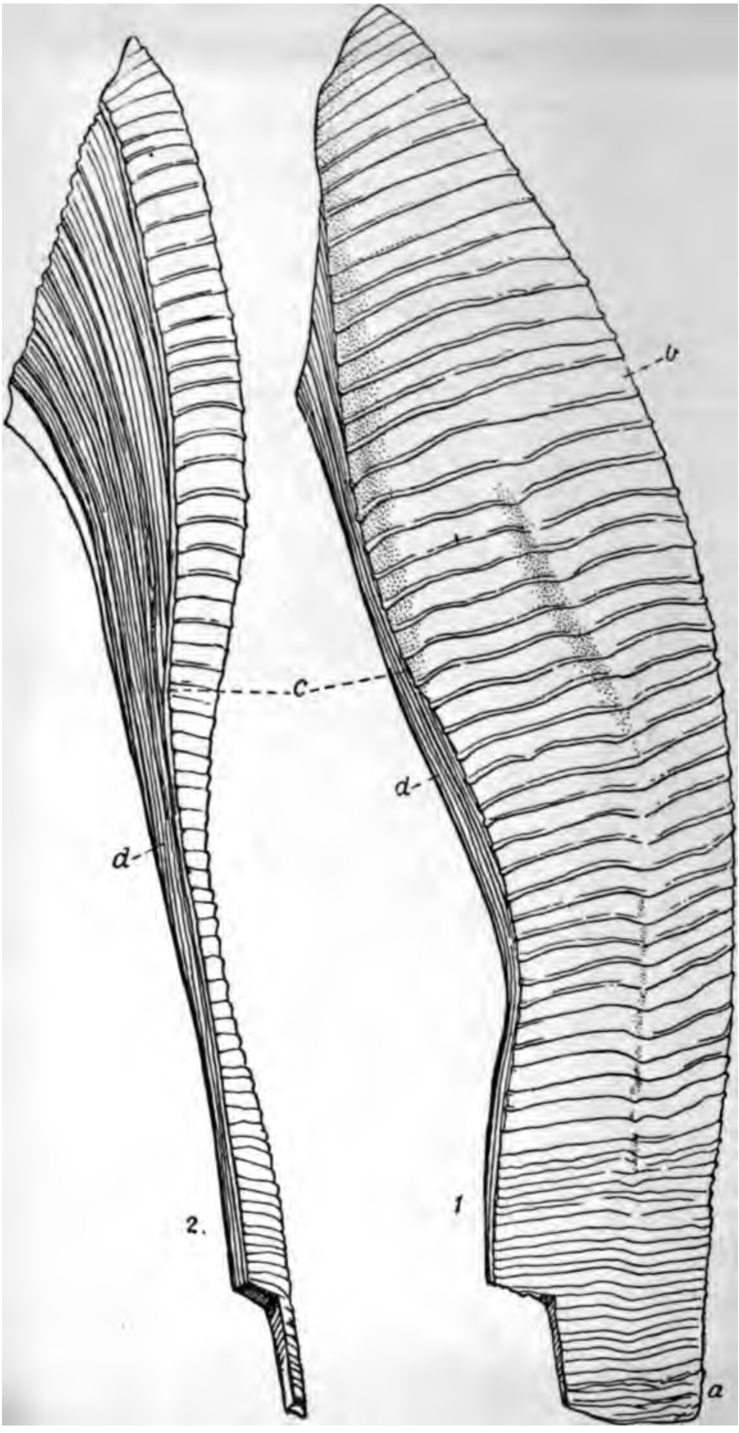
But there is no evidence to show that these plates belong to one and the same individual.

(*a*) *The Carina.* (Pl. X, Figs. 3–7.)

This valve is represented by one almost complete specimen and another less complete, and some broken fragments.

The more complete valve consists of a median, transversely ridged roof-plate, a 'tectum' (of Darwin), with a pair of inflexed 'parietes' forming a flange on either side.

The tectum is long, narrow, nearly flat at the basal extremity, but much arched from side to side distally. It is gently curved in the longitudinal direction, but there is no evidence to show that it was angularly bent upon itself. The basal extremity is uninjured; the inner surface slopes gradually to meet the outer surface, so that



A *giant* Cirripede (*Pollicipes*? *Aucklandicus*) from Tertiary Beds, Auckland, New Zealand.

Natural size

a rough but definite edge is here formed. The breadth of the tectum remains nearly uniform over the lower half, but widens very slightly near the middle; it then diminishes very gradually towards the distal portion; although the apex is absent, it was probably about half the breadth of the base. The lines of growth are practically transverse, and, as frequently is the case, those near the middle are more widely spaced than at the proximal extremity, where they are rather oblique.

The parietes are nearly complete, but are partly broken away near the distal extremity. Seen laterally, each parietes is practically a triangle, with a very long curved base, attached, of course, to the margin of the tectum. The lower or proximal side of the triangle is longer than the distal, and is slightly excavate, i.e. it is not a straight line. The distal side, as far as can be judged, is a straight line; what is left of it appears to be uninjured. The lines of growth on each parietes are very close set; starting from the basal extremity they at first run nearly straight, but slightly obliquely, upwards; then, where the flange widens out, they curve outwards and bend abruptly backwards, terminating along the distal side of the triangle. There is thus left a small smooth 'bay,' triangular in form, on the proximal side of the apex.

There is no ridge, but the surface suddenly drops along the line of junction of tectum and parietes; the angle formed by each of the latter with the former is about 135°.

The upper end of the valve is broken, but if the tectum be produced to meet the production of the distal side of the triangular parietes, the point of union will add about 25 mm. to the total length of the carina.

The inner surface of the valve is, in its upper half, marked by a series of fine transverse ridges and furrows; at the actual point of bending there is a narrow and well-defined ridge, while below, the surface is smooth.

The following measurements were made:—

		mm.
Length of fragment...		133
Probable total length	about	160
Greatest breadth of tectum...		18
Breadth at base		15
Breadth at fractured end		10
Thickness		2
Parietes—greatest breadth ...		25

(*b*) *The Scutum.* (Pl. IX, Figs. 1–2.)

This valve is 7½ inches in length, and only 1½ in breadth; it is thus remarkably narrow in proportion to its length. It will be convenient to distinguish a 'main plate' from a 'flange' which exists on one side, and is scarcely seen when the valve is looked at squarely from above; this 'flange' is the greatly inflexed latero-tergal region of the valve, which is set on to the 'plate' at an angle of about 115°. The 'main plate' is almost complete. There appears to have been a small apical region broken or worn away; but apart from this, and a small rectangular portion broken off the base which does not affect the shape or measurements, the valve is entire.

The basal margin is straight; the lateral and occludent margins form right angles with it, and are therefore parallel for the lower third of their course. The occludent margin, as a whole, is a continuous convex curve; while the other margin of the main plate is doubly curved, so as to form an S-shaped line, which is at first parallel with the occludent margin, then bends away from it, and finally curves gently towards it, so that a blunt apex is formed.

The surface of the plate is nearly flat from side to side in its proximal region, but is distinctly convex as the distal extremity is approached. Moreover, when viewed from the side, the plate exhibits a gentle S-shaped bend, the middle of it being concave outwards, the upper and lower ends convex.

The lines of growth are transverse, nearly straight, and are sufficiently prominent over the greater part to form slight ridges, but these become evanescent towards either end, and at the same time the growth-lines become closer together, especially as the basal margin is approached, where they are very crowded.

The 'flange' or tergo-lateral region of the scutum is very much inflexed, forming, as I have stated, an angle of about 115° with the main plate; it is somewhat thinner than the latter, and is triangular in form; the apex of the triangle, the tergo-lateral angle, i.e. its widest part, where it is 20 mm. across, is at the same level as the widest part of the main plate; the proximal side (lateral margin) passes down and soon becomes nearly parallel to the side of the plate, whilst its distal side (tergal margin) is shorter and passes to the apex of the main plate.

The flange differs in appearance from the plate itself, owing to the direction and character of the lines of growth; these are very fine and close together, their general course is longitudinal, but gradually curving outwards to reach the tergal margin, where their ends constitute a slight ridge; this margin is, I believe, the true uninjured edge. In thus curving outwards a small smooth bay is left on the proximal side of the tergo-lateral angle.

I have been unable to examine the inner surface of the valve, as it is closely attached to the matrix, but the concavity extends up to the apex.

The following measurements were taken:—

	mm.
Total length of scutum	187
Greatest breadth of main plate	38
Basal breadth	30
Thickness at base	2·25
Thickness at apex	1
Greatest breadth of flange	20

(*c*) *The Rostrum* (?). (Pl. X, Figs. 8–9.)

This valve is undoubtedly one of the median plates of the inferior series; it may be either the rostrum or sub-carina. It is much smaller than the preceding valves, is quite symmetrical and hastate in form; the longer axis is median, and the shorter axis much nearer the broader end. One end of the plate is sharply pointed, while the opposite angle is much more obtuse.

The valve is arched in the longitudinal direction, and is markedly convex from side to side; at the broader end a distinct but low keel occupies the median line.

The surface is marked by closely set lines of growth angulated in the middle line, the angle being directed towards the broader end.

	mm.
Length of rostrum	45
Greatest breadth	13

(*d*) *One of the Lateral Valves.* (Pl. X, Figs. 10–11.)

One of the valves, which at a first glance somewhat resembles the apex of a scutum, is doubtless one of the series of lateral plates, very probably the 'upper latus.' Unfortunately it is imperfect, but so much of it remains that it is possible to get an idea of the shape, though not, perhaps, of the size, of the perfect valve. Like the scutum, it consists of a 'chief plate' and a 'flange,' which, however, lie nearly in the same plane.

The 'chief plate' is long, narrow, and symmetrical, about a median line; one end is broken across, the other is a blunt point. The two lateral margins are symmetrically curved, nearly parallel at the fractured extremity, but gradually approximate in the opposite direction, so as to form feebly convex margins. The plate is marked by nearly transverse growth-lines, which in the proximal moiety are slightly distorted by a linear depression cutting across them nearer one margin than the other. This depression traverses about one-half the length of the plate, at first parallel to the margin, but later bending away from it towards the middle line.

On one side of the main plate is a thinner, narrow flange, triangular in general form; it is in reality merely the slightly inflexed margin of the valve, and, as in other cases, the lines of growth take a different direction from those on the main plate, passing obliquely upwards to cut the distal side of the triangle, which is uninjured, and slightly thickened.

	mm.
Length of fragment	70
Breadth of main plate	22
Greatest breadth over all	30
Thickness	1·5

Remarks.

Having given an account of these valves, I will proceed to consider those characters which may enable us to place the fossil in its proper genus. The question naturally arises, is the fossil a member of the genus *Scalpellum*, or is it *Pollicipes*?

In his classic monograph on the fossil Cirripedes, Darwin[1] points out the difficulties of deciding the matter when only a few valves are available; and in his work on the living forms,[2] he also

[1] "A Monograph on the Fossil Lepadidæ": Palæont. Soc., 1851.

[2] "A Monograph on the sub-class Cirripedia (Lepadidæ)": Ray Soc., 1851.

indicates the difficulty of drawing any hard and fast line between the two genera. In fact, one of our New Zealand species, *Scalpellum villosum*, is the very stumbling-block that he discusses. Nevertheless, Darwin, from his great experience in identifying these Cirripedes, indicates certain characters on which he relies, at any rate for fossil forms, in discriminating between the two genera.

In speaking of the *carina*, Darwin thus characterizes it for fossil species of *Scalpellum* (p. 17): it is "narrow, widening but little from the apex downwards, slightly or considerably curved inwards"; and adds further down the same page that "the chief character by which the valve can be recognised as belonging to *Scalpellum* is the distinct separation, by an angle often surmounted by a ridge, of the tectum from the parietes, which are either steeply inclined or rectangularly inflected; the lines of growth on the parietes are oblique."

On the other hand, in *Pollicipes* the carina is described (p. 49) as being "either bowed inwards or is straight; it widens from apex downwards more rapidly than in *Scalpellum*; generally a considerable upper portion projects freely, and this portion is always much less concave than the lower part." Further on he says, "the parietes are generally more or less inflected, but they are not separated by any defined ridge or angle from the tectum. Lines of growth on the parietes are transverse or only slightly oblique."

From these two quotations it would appear pretty certain that the carina described above would be attributable to the genus *Scalpellum*. But in examining the plates illustrating this genus we find in none of the species a carina that resembles that under discussion.

The present fossil has not only a much narrower tectum, but the difference in width at the two extremities is very much less than in any figured. The base, and therefore the lines of growth, are in the latter angulated, instead of being transverse as in our fossil. Again, the parietes are in most of the figures scarcely, if at all, visible in a dorsal view of the valve, since they are much more steeply inclined to the tectum than in the present instance. Further, the parietes in Darwin's species of *Scalpellum* is either a continuously curved plate of nearly equal width throughout, or its edge forms a chord to the arc of a circle described by the tectum.[1]

In our fossil we do not know with absolute certainty the true curve nor the true length of the carina, nor the position of the umbo; nevertheless, the appearance presented by the oblique margin of the distal moiety of the parietes leaves little doubt but that it is the natural, uninjured margin. If this be the case, and if we suppose this edge to be produced to meet a continuation of the tectum, we shall obtain the true form and size of the whole valve, which is not greatly curved nor much longer than the portion preserved, while there is no reason to doubt that the umbo is terminal.

Now it is a distinctly remarkable fact that the only carina figured by Darwin that does bear resemblance in the points above referred to is attributed to the genus *Pollicipes*, viz. *P. reflexus* (see pl. iii, figs. 8*a*–*c*). In this species, as in one or two others, the lines of growth, and therefore the base itself, are transverse and straight; the parietes are seen from above, and, though not precisely like those of the present fossil, yet bear a closer resemblance to it, in possessing a slight angle on its margin, than do those of any of the species of *Scalpellum*; while the inclination of the parietes to the tectum, as represented in the transverse section, is also similar, as is the general direction of the lines of growth, though the angulation of these, which occurs in our fossil, does not appear to exist. It is, moreover, the only Tertiary *Pollicipes* described in the monograph, having been found in the 'upper marine Eocene' at Colville Bay, Isle of Wight.

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[1] There is one exception, *Sc. magnum*, in which, however, the umbo is not terminal as it is in the rest, and as it is, in all probability, in our fossil.

The *scutum*: in its greatly elongated and much narrowed form this valve is quite unlike that of any of the fossil species either of *Scalpellum* or of *Pollicipes* figured by Darwin; but among living species *Sc. album*, Hoek,[1] has a very similar valve, so far as its general proportions are concerned. But what seems to distinguish our valve as much as any other feature is the very marked inflexions of the tergo-lateral region; in most of those figured by Darwin this 'flange' appears to lie very nearly in the same plane as the 'chief plate' itself; although in the description of some of the species, e.g. *Sc. arcuatum* and *P. Angelini*, he states that the "tergo-lateral portion is inflexed."

Darwin, in his diagnosis (p. 17) of *Scalpellum*, says, "scuta very slightly convex, four-sided, tergal and lateral margins being divided by a slight angle"; whereas *Pollicipes* (p. 48) possesses scuta which are "generally three-sided, but sometimes, either from the baso-lateral or rostral angle being truncated, there is an additional side. The tergo-lateral margin is either straight or, generally, more or less convex, but it is never divided into two distinct margins."

Now, if our scutum be examined merely from the outside, the tergo-lateral margin is scarcely angulated, and the general outline (except for its great elongation) resembles the scutum of *P. Angelini* or *P. acuminatus* much more nearly than it does any of the figures of *Scalpellum*. If, however, it be viewed from the side there is a more distinct angle, but even this is not so pronounced as in *Scalpellum*, in which the part that I have termed 'flange' appears to be less differentiated than in our species or in the genus *Pollicipes*. On the whole our valve seems to agree rather with that of *P. Angelini* than with any other fossil Cirripede. In his description of the scutum of this species Darwin writes (p. 57): "The tergo-lateral portion of the valve, formed by the upturned lines of growth, is not much developed; the tergo-lateral margin, as seen externally, is obscurely divided into two lines, of which the upper or tergal portion has its edge reflexed."

In reference to the other two valves described, very few words are necessary. The one which I suggest is 'rostrum or sub-carina' is, like our other valves, much narrower than in other species, either of *Scalpellum* or of *Pollicipes*. Of the former, only the rostrum of one fossil species is known, though, as Darwin pointed out, others probably possessed it. Amongst living species some have and others have not a rostrum. In *Pollicipes*, he says, the rostrum "resembles the carina, but is shorter and proportionately broader." Of the sub-carina we have practically no information.

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[1] Hoek: "The Cirripedia (Systematic Part)," *Challenger* Reports, 1883, viii.

The form of the latera is very varied in both genera, but only in a few cases are the lines of growth straight, as in *P. glaber* (pl. iii, figs. 10*f*, *k*), where it is nearly a right-angled triangle. In any case, it seems unlikely that these valves will have a diagnostic value.

It occurred to me that some relation in length might exist between carina and scutum, and that a comparison of this relation in *Scalpellum* on the one hand and *Pollicipes* on the other might aid me in determining the genus of the fossil.

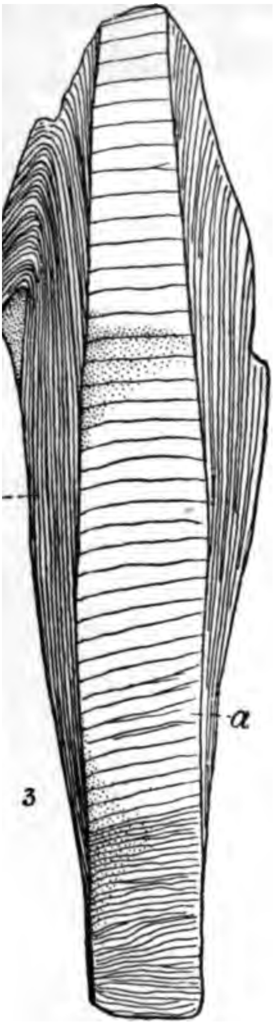
But an examination of the material contained in Darwin's monograph of the fossil forms soon showed the unreliability of this method of investigation as applied to them, for it is extremely rare to find a complete capitulum or a set of valves *in situ* which can be, without any doubt, attributed to an individual. Indeed, only two species of *Scalpellum* and one of *Pollicipes* in this condition are recorded by him.

Further, even in the case of figures of the entire capitulum of living species it is not always possible to measure with absolute accuracy the various valves. Nevertheless, from the figures given below, derived from measurements of Darwin's and Hoek's representations of the species, a certain proportion—not by any means a constant proportion, however—may be deduced in regard to the relative lengths of carina to scutum.

It will be seen that in *Scalpellum* the carina is always longer, usually much longer, than the scutum; whereas in the case of *Pollicipes* these two plates are much more nearly, or even actually, of the same size.

	[Length of capitulum, 100.]	
Scalpellum.	Length of carina.	Length of scutum.
vulgare	83	58
rostratum	83	58
ornatum	77	55
Peronii	77	55
rutilum	87·5	62·5
Stroemii	80	50
Japonicum	89	64
recurvirostris	89	53
Darwinii	78	58·7
regium	90·9	60·6
eximium	82·5	75
gigas	85	57·5
tritonis	93·4	54·8
Pollicipes.		
spinosus	71·2	71·2
cornucopia	70	70
polymerus	75	62·5

In attempting to apply this method of comparison to the valves under discussion, we are in this dilemma, that we do not know—in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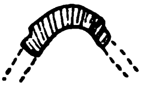
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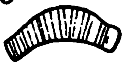
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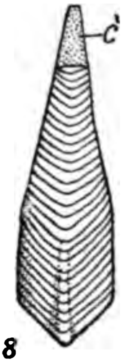
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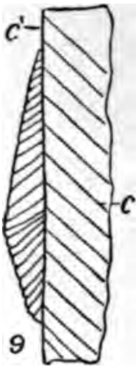
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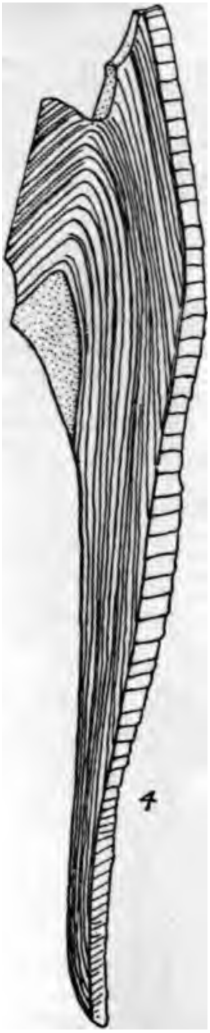
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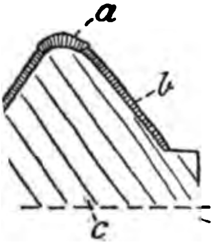

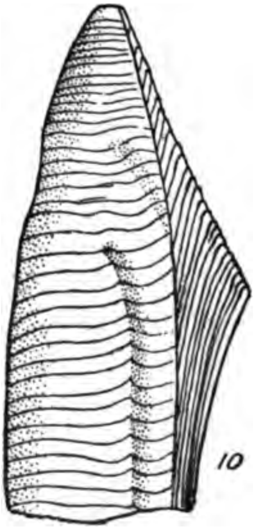
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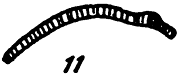
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nt Cirripede (*Pollicipes*? *Aucklandicus*) from Tertiary Beds,
Auckland, New Zealand.

arina ; *Figs.* 8–9, the rostrum ; Figs. 10–11, the latus (?). All figures fact, we have strong reason to doubt—whether these valves belong to one and the same individual. But it is, at any rate, noteworthy that the only scutum and the only approximately entire carina in this small collection should agree so nearly with the conclusions derived from a study of *Pollicipes*, for the scutum measures about 190 mm. and the carina about 160 mm., allowing for the probable damage at the end.

In other words, we are more likely to find in the entire capitulum of this fossil that these two valves are nearly equal in length, than that the carina greatly exceeds the scutum in length, as is the case in the genus *Scalpellum*.

So far, then, as this rough calculation goes, it bears out the view expressed above that the fossil belongs to the genus *Pollicipes* as defined by Darwin in dealing with the fossil pedunculate Cirripedes. For a determination of this point, however, we must await the researches of those who have a larger supply of material at their command.

EXPLANATION OF PLATES IX AND X.

Fig. 1.—The left scutum of *Pollicipes* (?) *Aucklandicus*, viewed from the outer side, showing the form of the 'chief plate.'

Fig. 2.—The scutum, seen edgewise, to show the outline of the 'flange,' or much inflexed tergo-lateral margin, as well as the general curvature of the plate. *a*, basal margin; *b*, occludent margin; *c*, tergo-lateral margin; *d*, 'flange.'

Figs. 3–7.—The carina. Fig. 3, dorsal view. Fig. 4, side view. Fig. 5, the basal margin, seen end on, to show form of tectum. Fig. 6, the fractured edge, to show the curvature near the distal region. Fig. 7, transverse section of another specimen of smaller size, at about the level of the middle of the valve.

Fig. 8.—The rostrum, external view; a small portion of the apical region is broken away, but the impression (*c*′) on the rocky matrix shows the length of the missing part.

Fig. 9.—The rostrum, side view.

Fig. 10.—The doubtful 'latus,' broken across its lower end, external view.

Fig. 11.—The same, viewed from the broken end.

V.—On the Origin of the Mosasaurs.

By Baron Francis Nopcsa, Jun.

Concerning the origin of the Mosasaurs three altogether different views exist: G. Baur regarded the Mosasaurs as highly specialized aquatic Varanoids; Boulenger is inclined to trace their origin back to the Neocomian Dolichosaurs; and Osborn, in a recent paper, doubts that Varanids and Mosasaurs sprang from a common stem, and regards the latter as "a very ancient offshoot of the Lacertilia." Some Lacertilia found in recent years in the Lower Cretaceous of Dalmatia, and not yet fully compared with the Mosasaurs, will, I believe, throw fresh light on this subject. Among the fossil Lacertilia found in Dalmatia two types can be distinguished, namely, Dolichosaurs and Aigialosaurs, the former including the genera *Dolichosaurus* Owen, *Pontosaurus* Gorjanovic-Kramberger (=*Hydrosaurus lesinensis*, Kornh.), *Acteosaurus* Meyer, and *Adriosaurus* Seeley; the latter, *Aigialosaurus* G.-Kramberger, *Carsosaurus* Kornh., *Opetiosaurus* Kornh., and perhaps also *Mesoleptos* Cornaglia.[1]

The following chief differences are observable between these two types:—

DOLICHOSAURS.	AIGIALOSAURS.
Skull relatively small.	Skull relatively large.
Quadrate bone probably slender.	Quadrate round as in Mosasaurs.
Mandible slender.	Mandible strong.
Teeth thecodont?	Teeth in sockets.
Vertebræ: neck remarkably long, consisting of 13 vertebræ.	Neck short, composed of only 7 vertebræ.
26 dorsal vertebræ.	21 dorsal vertebræ.
Ribs: dorsal ribs equally long and relatively short.	The long dorsal ribs vary in length.
No ventral ribs.	Ventral ribs well developed.
Limbs: anterior limbs much reduced in size.	Anterior limbs comparatively long.
Hind-limbs twice as long as fore-limbs.	Only somewhat longer.
Metatarsal v not showing Varanid modification.	Metatarsal v showing distinctly Varanid modification.

According to the description here given the *Dolichosaurus*, as pointed out by Osborn, cannot be the ancestor of the Mosasaurs, whereas the same cannot be said of the Aigialosaurs. The most remarkable points of resemblance and difference between the Aigialosaurs and Mosasaurs are as follows:—

AIGIALOSAURS. MOSASAURS.

Skull: *upper surface* in both cases perfectly the same and strongly resembling the Varanids. *Quadrate bone* in both types broad and flattened, thus differing from the same bone in the living Varanidæ. *Articulation between the front and hind parts of the mandible* present in both types and absent in the Varanidæ.

AIGIALOSAURS.	MOSASAURS.
Vertebræ: 7 cervical vertebræ, no sign of primitive structure; 21 dorsal vertebræ, like those of the Varanidæ.	Seven cervical vertebræ, showing very primitive structure (due to pelagic life?); dorsal vertebræ varying from 22 (*Tylosaurus*) to 36 (*Clidastes*).

Ribs: the sternal ribs are equally developed in both, and their position indicates in both cases the same kind of sternum, with this difference:—

AIGIALOSAURS.	MOSASAURS.
Sternum broad and large; 6 sternal ribs touching the sternum.	Sternum comparatively small; 10 true sternal ribs present.
Shoulder-girdle well developed.	Shoulder-girdle somewhat reduced.
Fore-limbs intermediate between the Mosasaurid and Varanid type.	Fore-limbs changed to paddles.
Pelvic girdle well developed.	Pelvic girdle reduced.
Two sacral vertebræ present.	Only one sacral vertebra.
Hind-limbs like front-limbs, both extremities bearing sharp claws.	Hind-limbs paddles; hyperphalangy, and no claws present.

Dermal covering consisting in both cases of rhomboidal scutes bearing a slight median elevation.

It is thus evident that the *Aigialosaurs show great affinity to the*

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[1] This classification does not correspond with the one given by Gorjanovic-Kramberger.

Mosasaurs, differing from the latter only in not being as thoroughly adapted for pelagic life. On the other hand, the *Aigialosaurs show*, as remarked by Kornhuber, *a strong resemblance to the living Varanids, differing from these only in those points by which they approach the Mosasaurs.*[1]

The question arises now, do the Aigialosaurs represent the most primitive Mosasaurs or a family in the suborder of the Lacertilia? Taking the Mosasaurs, on account of the development of their paddles, as a distinct suborder of the Squamata, the Aigialosauridæ would prove to be a distinct family among the Lacertilia, approaching greatly the Jurassic type from which the Cretaceous Mosasaurs and the recent Varanidæ are the offspring. This type, being terrestrial, would of course bear greater resemblance to the modern Varanids than to the pelagic Mosasaurs.

A paper dealing more fully with this highly interesting subject is to appear in the Geolog. und Palaeontolog. Beiträge in Vienna.

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[1] It cannot be certainly known whether the pterygoids of the Aigialosaurs bore teeth, but I am inclined to believe they did, since in *Opetiosaurus* the crown of a tooth lying near the hyoid bone (= columella of Kornhuber) seems to differ in size both from the mandibular and (presumably also) maxillary teeth of this animal.

VI.—THE GEOLOGICAL CHRONOMETER.

By G. W. BULMAN, Esq.

THE pleasant relations normally existing among geologists, biologists, and physicists have of late become a trifle strained on the question of the age of the earth. Biologists, having failed to induce either geologists or physicists to draw sufficiently large cheques on the bank of time, have taken to signing the same themselves, adding the ciphers *ad lib.* Professor Poulton has ably championed the rights of the biologists to do so,[1] and in the course of his argument he contends that there is evidence in the sedimentary strata to show that their rate of formation was *not* greater than that at which deposits are now being accumulated.

So far as I am aware, Professor Poulton's contention has not been either controverted or supported by any geologist. Hence it seems to be a suitable subject for discussion in the GEOLOGICAL MAGAZINE.

In the first place, then, what would be the nature of the evidence we might *a priori* expect to find to show that one set of beds was accumulated in a shorter time than another of equal thickness? Would there, in fact, be any difference such as would enable us positively to decide the question?

Secondly, we may examine and compare rocks which we know, or have reason to suppose, have been formed at different rates. Now, according to Sir A. Geikie, if the rocks of the stratified systems were laid down at the greatest rate suggested by the facts of denudation, 73,000,000 years would be required; if at the least, 680,000,000. In other words, the greatest rate of formation is more than nine times the least. We ought, then, to be able to put the question to the test of actual observation. Do the deposits formed at the greater rate differ in any essential characters from those formed at the lesser? If we can establish any difference by observing recent deposits, then we can apply the criterion to the strata of past ages. But, so far as I am aware, no geologist has pointed out any specific characters by which a quickly formed deposit can be certainly distinguished from a slowly formed one. This may be, of course, that they have not specially looked for such characters. It seems more probable, however, that there are no reliable criteria.

"The geological agency to which attention is chiefly directed by those who desire to hurry up the phenomena of rock formation," Professor Poulton tells us, "is that of tides." And to prove that tides were not sufficiently high in time past to do so, two things are relied on.

First, that the rocks indicate deposition under *tranquil* conditions, and secondly, that "extremely delicate organisms" are found in them.

"There are, then, among the older Palæozoic rocks a set of deposits than which we can imagine none better calculated to test the force

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[illegible] Presidential Address to the Biological Section (D), Brit. Assoc., Liverpool, 1896.

of the tides; and we find that they supply evidence for exceptional tranquility of conditions over a long period of time."

But, we ask, would the existence of higher tides necessarily destroy this appearance of tranquility? There is, so far as I am able to grasp the facts of the case, no grounds for supposing that higher tides would prevent tranquility of deposition. But we can put the matter to the proof. We have deposits which have been laid down in lakes and inland seas where there are no tides. Do these show the marks of tranquil deposition—whatever these are—to a greater degree than those of the open ocean? Would any geologist be able to distinguish the deposits of the Mediterranean as having been laid down under more tranquil conditions than those of the Atlantic?

As regards the extremely delicate organisms which, Professor Poulton remarks, are found in the Silurian, it is difficult to realize how a higher tide would affect them. And it is not quite clear whether it is the fact of these delicate organisms having lived or their having been preserved which is supposed to show that the tides were not appreciably higher in Silurian times. Professor Poulton's exact words are:—

"The remains of extremely delicate organisms are found in immense numbers, and over a very large area. The recent discovery, in the Silurian system of America, of trilobites, with their long delicate antennæ perfectly preserved, proves that in one locality (Rome, New York State) the tranquility of deposition was quite as profound as in any locality yet discovered on this side of the Atlantic."

If the higher the tide the less delicate the organism capable of living in the water, then the organisms of the Mediterranean ought to be more delicate than those of the Atlantic. Here, then, we can appeal to facts. As the question is outside the scope of my knowledge I must leave it in the form of a query. But, so far as my geological knowledge carries me, the fossils of lake and inland sea deposits are not of more delicate organization than those found in the strata of the open ocean.

And if the finding of a few of the "long delicate antennæ" of trilobites in America proves the profoundness of the tranquility, what does their universal absence in this country show? Again, there arises the question of the relative delicacy of the organisms of the Silurian. Have we the right to say they are as delicate as some of the organisms of our present seas? Can we, for example, really say from what we know of their remains that the graptolites were not able to stand more tossing about—assuming for a moment that higher tides would make it more tempestuous — than the *Sertularia* of our present seas? The chitinous rod of the graptolite *may* have been very tough and strong. We have no means of measuring its strength. It must be left an open question whether or not it was fitted to live in a more stormy ocean than the present.

Again, Professor Poulton says:—"Thus the attachments of marine organisms, which are permanently rooted to the bottom or on the shore, did not differ in strength from those which we now find, an indication that the strains due to the movements of the sea did not greatly differ in the past."

But have we any grounds for speaking positively on this point? Take, for example, the ligaments by which the Brachiopoda are attached to the sea bottom. We can measure the strength of the cable of an existing terebratula, but we have no means of testing the strength of the strand which anchored *Terebratula hastata* to the bed of the Carboniferous ocean. The actual cable is no longer there; it is a mere impression, a cast, or chemically altered. And certainly the anchored Mollusca—the Brachiopoda—were more numerous in the early geological ages than other classes, while they are comparatively rare at the present day.

Again, Professor Poulton brings forward evidence of a similar kind to show that movements of the air were not greater in the geological past. "We have evidence of a somewhat similar kind to prove uniformity in the movements of the air. The expanse of the wings of flying organisms certainly does not differ in a direction which indicates any greater violence in the atmospheric conditions."

Quoting the case of the island of Madeira, where an unusually large proportion of the beetles are wingless, and those which fly possess the powers of flight in a higher degree than those on continental areas, he leads us to the conclusion that if there had been greater air currents there would have been a like state of things in the geological past, with regard to winged creatures in general.

The evidence is rather slender for the conclusion which is built on it. For, as regards fossil organisms, it is the mere relative expanse of wing we have to go by. But suppose it was set us as a mechanical problem, "Given a flying organism, to fit it for more stormy conditions," how would we endeavour to solve it? Increase the size of its wings? That might only the better enable the wind to blow it away. Diminish them? That would curtail its powers of independent flight. The only solution would appear to be to increase the strength of the muscles, diminish the weight so far as consistent with strength, or alter the shape of the wings. All these things *may* have occurred in the ancient fliers.

Again, Professor Poulton quotes Professor G. Darwin to the effect that the size and strength of the trunks of fossil trees afford "evidence of uniformity in the strains due to the conditions of the atmosphere." But I maintain that, although we can measure the *size* of a *fossil*, we cannot from it accurately gauge the *strength* of the *living organism*. The original substance is no longer there, or there only in part. And we know from our existing vegetation how vast a difference there may be in the general form of the trees which are able to stand the present atmospheric strain. But this question of possibly greater atmospheric strain in the past does not seem to be of great importance, as no geologist who has protested against over strict uniformitarianism has laid much stress on it.

And besides tides and winds, there are other geological agents which *may* conceivably have been more active in the past.

[illegible]) Rainfall. There certainly must have been a time when evaporation — owing to greater heat of the earth, and consequently rainfall—was greater. Only if this state of things is shifted back beyond the period of the formation of our earliest stratified systems, can we escape the conclusion of greater geological activity in the past. And the greater the rainfall the greater the denudation, and consequent rock-making. This quicker formation, again, would probably not be shown in the rocks themselves.

(2) There may have been a larger amount of CO_2 in the atmosphere. In the original atmosphere of the globe there was probably a very large quantity of this gas. There *may* have remained in the atmosphere of the early geological ages an amount far in excess of the present supply.

(3) There may have been greater exuberance of life when the waters of the ocean were warmer, as they once must have been on the hypothesis of a cooling globe.

Greater rainfall, more CO_2 in the atmosphere, and a warmer ocean, all *must* once have been: they *may* have been late enough in time to affect the rate of deposition of the known stratified rocks. The question, then, really is, are we justified in putting them so far back as to make them anterior to the beginning of geological history? Those who are demanding more and more time must remember that the longer the period granted for the laying down of the stratified systems, the nearer we get to the epoch when the activity of geological agents *must* have been considerably greater than it is to-day. And if they *assume* that all the known stratified rocks were formed at the present slow rate of deposition, they leave unaccounted for the great series of strata which must have been laid down when geological activity was greater. They must appeal not merely to the imperfection of the record, but to its total absence so far as concerns the period before the present slow rate of deposition began.

Professor Poulton is at great pains thus to cut away the ground under the feet of the geologist who would "hurry up the process of rock formation." But even granting all that is claimed to have been proved, the biologist only gets in this way some 400,000,000 years. And this is so obviously too little that it seems hardly worth while to have troubled the geologist at all. Speaking of that curious organism *Peripatus*, which has been variously classed in the zoological scheme, Professor Poulton says:—"*Peripatus* is not known as a fossil. *Peripatus* has come down, with but little change, from a time, on a moderate estimate, at least twice as remote as the earliest known Cambrian fossil."

Now, if we put back the origin of *Peripatus* to a time as far anterior to the Cambrian as the Cambrian is to the present day, how far must we put back the origin of the simplest form of life? Well, *Peripatus* is a somewhat advanced organism—about the level of the insects—and on the assumption, approved by Professor Poulton, that evolution is slower among the simpler organisms we should perhaps place the first appearance of life on the globe as much before *Peripatus* as the origin of *Peripatus* is before the present. This places the commencement of life at a point four times as remote from the present as the Cambrian. If, then, we take the period from Cambrian to present as 400,000,000, we get 1,600,000,000 years as the time during which there has been life on the globe. And there must have been a time anterior to this before life on a heated globe was possible. Yet Professor G. Darwin only allows 500,000,000 as the life of the sun!

Again, since we must suppose that rock formation began before life, what has become of the great series of pre-Archæan deposits which must have been laid down? Supposing for a moment that the Archæan rocks represent a period as long as from the Cambrian to the present, we have an interval as long as from the lowest Archæan to the present in which strata were being formed. Of this great series, which must have been, we know nothing. It is hardly conceivable that they should have entirely disappeared, leaving no trace behind. Time, we know, not only devoured his children, but also the stone offered in lieu of one of them. Yet we should hardly have supposed him capable of devouring quite so much rock.

Of course, no one can object to Professor Poulton, and those of like views, asserting that, on their hypothesis of the origin of the organic world, this or that organism must have existed so many million years ago, or at such and such a geological epoch. But if they are able, from the study of an existing form, to say positively that it must have existed at such a time, in spite of its entire absence in the known geological record—and even in spite of the absence of any geological record at all—it seems superfluous to appeal to geology at all. Biologists had better at once declare their entire independence. Professor Poulton practically does so. For after disposing of geology in the manner indicated he says: "We are therefore free to follow the biological evidence fearlessly."

One can only admire, while one wonders at, Professor Poulton's boldness. Geologists are yet sorely perplexed with the problem of the Archæan rocks. They have not yet definitely decided whether they are metamorphosed ordinary sediments, part of the original solidified crust of the earth, or chemical precipitates from a hot primitive ocean. Professor Poulton assumes, not merely that ordinary sedimentation, but *life* also was possible on the globe untold ages ere the earliest known pre-Cambrian rocks were laid down.

Darwin found Lord Kelvin with his 100,000,000 years an "odious spectre"; Professor Poulton apparently agrees with Butler that

> "There needs no other charm or conjurer
> To raise infernal spirits up but fear,"

and boldly waves back both geologist and physicist. He apparently adopts as his motto the advice of the Sybil to Eneas—

> "Tu ne cede malis; sed contra audentior ito
> Qua tua te fortuna sinet,"

which may be freely translated, "If facts go against you, *assume* the more boldly."

And so, having freed himself from both geological and physical evils, in the form of narrow balances at the bank of time, he holds himself free to go boldly where biological speculations permit. It is magnificent, but it is not science.

VII.—EOLITHIC IMPLEMENTS AT BELFAST AND AT BLOOMSBURY.

By F. J. BENNETT, F.G.S.

MR. J. W. KNOWLES, M.R.I.A., of Ballymena, read a paper[1] on what appeared to him to be flints chipped similarly to the eoliths, which he had found in the Interglacial gravels of Ireland. This gave rise to a discussion, in which five speakers in succession gave reasons, or rather expressed opinions, adverse to their artificial character; and as these seemed based on some misconceptions, and also as I was the only one who spoke for them, and was told I must be brief, and so could not fully reply to them, I do so in the present form, and I state, as far as I remember, what took place in as few words as possible.

Mr. Knowles himself took a neutral position, but suggested that, if they were implements at all, they might have been used as scrapers for scraping hæmatite.

The objections were: that these so-called eoliths were found in such extraordinary numbers that they might be the result of natural causes, and that their upholders must disprove this; that the flints in question were those of the Clay-with-Flints, a deposit due to the chemical dissolution of the Chalk-with-Flints; that, if admitted to be artificial, they could not be older than the Palæolithic implements of the high levels, as they were both found in the same deposits; that similar flints were to be found in the Boulder-clay, and, as man was post-Glacial, that was a positive refutation.

Professor Boyd Dawkins, LL.D., F.R.S., took a prominent part in the discussion, and it was from him indeed that most of the objections came.

Replying to the objections, I would say that, as to their extraordinary numbers, "in countless thousands" as had been stated,[2] that might be expected from their very rudeness. If these are the very earliest tools of the earliest men we should, on evolutional grounds, expect them to range from natural forms (selected in their first stages as adaptable to man's primitive needs, when first conscious that some tool as an adjunct to the hand would be a useful supplement to that member) to modifications by rude chipping of that natural form into more and more artificial forms; and these gradations are of course very difficult to follow. This renders it necessary that no opinion should be formed unless a large series of these so-called implements has been examined, such as Dr. Blackmore's at Salisbury (which converted two of my late colleagues) and Mr. Harrison's at Ightham. The latter, *none* of the objectors had seen, though by some misunderstanding the Section thought they had. As to their being all due to natural causes, such as ice-pressure, wave and river action, this objection has been very fully met by the late Sir Joseph Prestwich in his letter "Nature and Art," in the GEOLOGICAL MAGAZINE, Dec. IV, Vol. II, No. 374, p. 375, August, 1895. There he repeats a former challenge for anyone to produce half a dozen shore-flints of any of the plateau types figured in the five plates that he published in his "Collected Papers," and no one has yet produced these.

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[1] Paper read before British Association, Belfast, Sept. 1902.

[2] The new pit sunk by Mr. Harrison and myself last year at Parsonage Farm, Ash, confirms most fully those sunk in 1894. I took a careful note of the percentage of worked as compared with the unworked stones, and this varied from 4 to 9 per cent.; out of the many 'cart-loads' of stones got out the worked stones would not make even one barrow-load, and as a matter of fact this pit, sunk 12′×8′×5′, only yielded some 200 specimens. I understand that to the Eoliths exhibited at Bloomsbury a label is attached with these words, "Supposed to be the work of man." Now this might lead many to assume that the Palæoliths were undoubtedly the work of man, and yet there is no *real proof* of this, and the same words *might* apply to both Eolithic and Palæolithic implements (so-called).

Still, I might add, undoubted palæoliths have been found in beds where all these causes have had full play; not so certain, indeed, in the case of ice-action, though implements with parallel striæ similar to ice-markings are not uncommon; and where waves, as in the case of the Palæolithic implements found at the base of sea-cliffs, have bruised and battered them, man's work stands out still, and the same remark applies to implements found in the river-gravels. Besides this, no one has yet made a collection similar to Mr. Harrison's, of ice-, wave-, or river-formed specimens. As to the statement that they are similar to the flints (and this is what Professor Boyd Dawkins meant, I suppose) of the Clay-with-Flints, none have been found in this deposit; they are found in a distinct gravel-bed, at an altitude of 755 feet O.D. Then, as to the statement that Palæolithic implements are found in the same deposits as the high-level Eolithic implements, it is true that in one or two instances a Palæolithic implement was dug up, but how or when is not known. On the contrary, the evidence of the two pits sunk by Mr. Harrison in 1894, with the grant made by the British Association, shows that the gravel-bed at 7½ feet yielded a considerable number of Eolithic implements only, and the five additional pits sunk by Mr. Harrison to satisfy himself confirmed this. The objection that, as man is post-Glacial, therefore he cannot be pre-Glacial, is a mere dogmatic assertion. Again, the stony loam, the first bed met with in the above pits, cannot surely be Clay-with-Flints, as it rests on a gravel-bed, which lies on 27 feet of Tertiary beds, and *not on Chalk*, as Clay-with-Flints should.

Thus, I think that all the objections have been fairly considered and met.

But in spite of the opposition to the acceptance of the eoliths, Mr. Harrison and his supporters must be gratified to find them occupying so important a place in the recent Geological Survey Memoir on Sheet 314 of "The Geology of the Country around

Ringwood"; also in the British Museum, Bloomsbury, and Mr. C. H. Read's "Descriptive Guide to the Stone Age." In this Guide (an otherwise carefully written work) no provisional place has been given to the eoliths *before* the palæoliths in the classification, and the mention of these appears in the *middle* of the Palæolithic period; this must lead to confusion. Mr. Read seems impressed by the eoliths, and treats them most fairly, though it is very unfortunate that, while all the other illustrations are well done, the eoliths at p. 37 show in their drawing only feeble evidence of 'work.' Mr. Read, at p. 33, refers to the important collection of Eolithic implements from Sir Joseph Prestwich's collection in the Natural History Branch of the British Museum at South Kensington. This should be carefully studied as additional illustrations of the Stone Age.

REVIEWS.

I.—Recent Excavations at Stonehenge, communicated to the Society of Antiquaries by William Gowland, Esq., F.S.A., F.L.S., etc. With a Note on the Nature and Origin of the Rock-fragments found in the Excavations, by Professor J. W. Judd, C.B., LL.D., F.R.S., F.G.S. 4to; 93 pages, with 4 plates and 29 text-figures. Printed by J. B. Nicols & Sons, Victoria Street, Westminster, 1902.

THE Antiquary and the Geologist have individually for many years past published their observations on Stonehenge, and their notions about its origin and structure; but now, in actual co-operation, they have united to give a real description and sound opinion of this venerable monolithic monument of ancient labour and intelligence. With the consent and generous help of the Owner, the valuable assistance of willing experts, and the utilization of any useful information from among the already published notes, a great mass of authentic particulars has been thus collected and arranged to a good purpose.

The descriptive text (forming part of the Society of Antiquaries' Archæologia for 1902) is admirably printed, with numerous illustrations, several of which are produced from excellent photographs taken during the operations and kindly lent by a lady of the neighbourhood. Every stage of the excavations made around the foot of the prominent and well-known 'leaning stone,' which had to be restored to its original vertical position, as it was when a part of the chief Trilithon, has been described and figured in detail. Thus one of the chief objects of this important engineering undertaking has been carefully worked out. Another object to be attained was the realization of some definite history of the great standing stones of Stonehenge, as far as the relative number, position, and characters of the blocks and chips of the various kinds of stone got from the diggings can prove anything as to the cause, method, and time of their imbedment in the subsoil.

The large monoliths of the outer circle and the trilithons of the 'Horse-shoe' are of the well-known Sarsen Stone, namely, relics of concretionary masses of Tertiary Sandstone (probably of the Bagshot Sands, which once lay over the Chalk). They range in their structure from granular (saccharoid) to compact and quartzitic denseness. Sarsens having the latter character were found only in the diggings, as blocks and hammer-stones, used in shaping and dressing the monoliths, or as fragments of such hammers.

The small monoliths, commonly called 'the Blue Stones,' and forming the inner circle and the inner horse-shoe, consist of aqueous, schistose or metamorphic, and sedimentary rocks. At pp. 73–78 (1) the Sarsen Stones and their constitution are fully treated of by Professor Judd. (2) Ophitic diabase (p. 74) has been recognized, with varieties, in fragments and in a still standing stone. (3) The schistose and fissile rocks are highly altered basic tuffs and agglomerates (p. 74); their fragments are numerous, but only the stump of one of this sort of stone has escaped the action of weathering and other destructive agencies. (4) Fragments of altered rhyolites and diorites (p. 75), formerly often referred to as hornstones, etc., present various characters not readily determined, and indicate the former existence of a stone of this material. (5) Sandstone, grit, and conglomerate, including the micaceous sandstone of the 'altar-stone,' and probably equivalent to the Coronation Stone in Westminster Abbey, from the Old Red Sandstone of Perthshire, occur among the fragments. (6) Greywackés (p. 76), that is, granular quartz and altered felspar, with argillaceous matter, among the fragments, show that stones of such material were present, but probably were easily weathered away. (7) Argillaceous flagstones and slate (p. 76) must have been among the standing stones, but were completely weathered away, especially when their bed-planes and cleavages were set vertically. (8) Glauconitic sandstone (p. 76), probably of the Upper Greensand, occurred in a few fragments. (9) Flint, from the neighbouring Chalk (p. 77), was present as very numerous rough chisels and hammers, and the chips and fragments of such tools. Some small hammers of crystalline rocks and quartzite (hard sarsen-stone) were also found, and several large masses, the weight of which (upwards of 50 and 60 pounds) and the probable method of using them are given (p. 34).

The stone implements found at Stonehenge are carefully figured (23 of flint, 7 hard sarsen, and 1 argillaceous sandstone) at pp. 22–25; they are mostly blunted and battered by use. Flint tools corresponding in shape from Grimes Graves and Cissbury are figured at pp. 27–28.

Important observations are made (at pp. 37, etc.) on the modes of erection and the probable age of Stonehenge. The finished surfaces of all the Sarsens, where preserved, had been tooled with hard hammers, and the markings cannot be produced by present mason's tools (p. 43). The methods by which the great monoliths were set up and secured in the ground were shown in detail during the excavations as far as gone (pp. 44–48). The legend of the

'Blue Stones' having been brought from a distance and set up as a sacred circle, and the supposition that the Sarsens were added afterwards around them, are disproved by evidence of their contemporaneity, by the mode of occurrence of the chippings, and of the stones themselves.

The use of bronze was unknown before 1800 B.C., and there were no bronze tools found in the diggings. Mr. Gowland is therefore inclined to consider that Stonehenge was raised before the incoming of the Bronze Age at the above date. This nearly approximates with the result of the important astronomical investigation by Sir Norman Lockyer and Mr. Penrose as to the relative position of sunrise at the summer solstice and the probable age of Stonehenge.

Professor Judd, in his clear and comprehensive description of the stones of Stonehenge (pp. 70 et seq.), gives the bold but well-founded suggestion that all the stones once lay about on the surface of the district. The Sarsens, being the concretionary relics of the denuded Bagshot Sands, were large and abundant. The 'Blue Stones,' of smaller size and of various characters, were relics of the glacial Boulder-clay, which reached in the Southern Counties further than is usually described. The presence of similar rocks in the gravels of the rivers of the South of England, including those that drain Salisbury Plain, support this opinion. The absence of such rocks, foreign to the district, on the surface now, may be well accounted for. The softer rocks were gradually weathered away, and the harder kinds were continually being used for local purposes, like the existing scattered Sarsens in Berks and Wilts. These 'Blue Stones' were, moreover, evidently dressed on the spot when taken to the circle, for their chippings are more numerous than those of the Sarsens in some of the diggings. T. R. J.

II.—EGYPTIAN GEOLOGY.

Survey Department, Public Works Ministry, Egypt. Geological Survey Report, 1900. Part II: The Cretaceous Region of Abu Roash, near the Pyramids of Giza. By HUGH J. L. BEADNELL, F.G.S. 8vo; 48 pp., 13 pls. (Cairo, 1902.)

THIS is an attempt to give an adequate description of the geology of a small area lying to the west of Cairo. It is a district that has received the attention of many observers before, as Mr. Beadnell is careful to record in his historical sketch which forms an introduction. The report is accompanied by a geological map, which the author tells us is sufficient for present requirements. It is not possible for anyone who has not been over the ground to criticize the details of the stratigraphy, but it appears to have been carefully done, and numerous detailed sections are given which should render the work of great value to future observers. The author, too, has a topographical knowledge which is so exact as to allow him to write in a more interesting manner than is usual in official reports. It is a matter for regret that those who are engaged in a geological survey of a country do not also enjoy the advantage of some special palæozoological training. It is, as a rule, difficult for a surveyor to properly decide the exact age of the rocks among which he is working, unless he is himself able to name his own collections. We know that this was not formerly considered necessary even on the Geological Survey here at home, and much of the confusion of age which has arisen in various places is doubtless due to this indifference to the high importance of a constant reference to palæozoological guideposts and zone-marks. The system which demands that one man shall map everything from Archæan to Recent doubtless debars many geologists from anything more than a superficial acquaintance with fossils in the field, but that it is a necessary consequence is disproved by many well-known Continental names.

The report is illustrated in an admirable manner, and plates iii and vii (collotypes) are perfect, and show that Mr. Beadnell is also an expert photographer. The three plates of wind-worn pebbles are photogravures and excellent, but such ordinary objects seem scarcely worthy of the expense incurred; certainly one plate would have sufficed.

The Director-General of the Egyptian Survey and his staff may well be proud of the stratigraphical results of their labours; and in gracefully accepting the special knowledge of fossil forms afforded them by Dr. Andrews, Mr. Bullen Newton, Professor Gregory, and others, they cannot fail to enhance the high scientific value of the palæozoological results obtained in this most interesting and ancient country. C. D. S.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—January 21st, 1903. — Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Figure of the Earth." By William Johnson Sollas, M.A., D.Sc., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford.

The almost precise correspondence of great terrestrial features with a circular form seems to be frequently overlooked. The Aleutian curve has its centre in lat. 6° N., long. 177° W., that of the East Indies about 15° N. and 118° E., and round the latter centre are several concentric curves. The northern part of South America, the Alpine-Himalayan chain, the western shore of North America, and a portion of Australia may be similarly reduced to geometric form. A great circle swept through the centres of the East Indian and Aleutian arcs runs symmetrically through the bordering seas of Asia as far as Alaska, borders the inland lakes of America, passes the Californian centre, extends through the middle of the Caribbean Sea, runs parallel with the coast of the Antarctic Continent, and returns to the East Indian centre without touching Australia. This course is in remarkable correspondence with the general trend of the great zone of Pacific weakness. If the pole of this circle in the Libyan Desert is placed towards an observer in a globe, the African Continent appears as a great dome surrounded by seas and separated from the Pacific by an irregular belt of land. A second great circle defined by Lake Baikal, and with its centre at 'the morphological centre of Asia' of Suess, and passing through the East Indian centre, may be regarded as the direction-circle for the Eurasian folding. These two centres intersect at an angle of 39°, and, on bisecting this angle, a mean directive circle is found, with its pole near the sources of the White Nile, 6° north of the Equator. The axis of terrestrial symmetry through this pole passes through the middle of Africa and of the Pacific Ocean. The smallest circle which will circumscribe Africa has its centre near this pole, and within it the symmetry of the fractured African dome is observable. Outside this comes a belt of seas, and outside that again the Pacific belt of continents, the Antarctic, South America, North America, Asia, and Australia. Mr. Jeans has concluded on mathematical grounds that the 'pear-like shape of the earth' might have been possessed by it at the time of its consolidation; and he has suggested that Australia may represent the 'stalked end' of the 'pear.' The author's observations would lead him to place it in Africa, and to regard the Pacific as covering the 'broad end.'

2. "The Sedimentary Deposits of Southern Rhodesia." By A. J. C. Molyneux, Esq., F.G.S.

The greater portion of the area of Southern Rhodesia lies on granite and gneiss, and on the schists and slates that contain the auriferous veins worked in ancient times, and now being again opened up on an extensive scale. The remaining area is on sandstone and other sedimentary beds, with coal-deposits, and regions of volcanic rocks. To explain the deposition and order of these sediments several sections are given; one being along a line extending from the Zambesi River on the north, through Bulawayo and the central plateau, to the Limpopo River on the south, a distance of over 400 miles. Another section, with remarks thereon, is copied, by permission, from a report by Mr. C. J. Alford, F.G.S., on the coal-bearing rocks of the Mafungibusi District.

From Bulawayo fine sandstones continue for about 170 miles to the north, when there is a sudden drop in the surface of the country, caused by a long line of cliffs of red sandstone, which extends from the Zambesi Falls Road right across this portion of Rhodesia, and finally merges into the Mafungibusi Hills far away to the north-east. This is the great escarpment, formed by the erosion of 400 feet of coarse grit with angular pebbles. To the north-west of this escarpment, and running parallel with it, is a long and narrow valley formed of soft shales which are known as the Matobola Flats. Here the beds dip at 5° south-eastward. Thus, in proceeding further to the north-west, underlying beds are revealed, with a lower series of Coal-measures containing seams of workable coal. Below the Coal-measures are quartzites and current-bedded grits, which rise up and form the Sijarira Range, a flat plateau 15 miles across. Its north-western side, however, is almost precipitous, and is capped by folds of quartzites. There is a drop of 1,100 feet in a few miles, and the rest of the country is almost flat as far as the Zambesi River. To the west is the gorge of the Lubu River, and it is there seen that the sediments rest upon pegmatites and gneiss.

Another section shows the contact of fine sediments and metamorphic rocks down the railway-line to the south-west past Sisi siding, where certain plant-remains were found. By these sections the boundary or line of unconformity is traced from the Mafungibusi district, round the promontory of granites and shales which form the backbone of Matabeleland, to the Tuli district and Sabi River on the south. Except in the Tuli district, where an unconformity between the veined sandstones and the Coal-measures is noticed, there are no definite breaks in the order of stratification; and it is by the general arrangement of superposition and characteristic features that the strata fall into certain groups. No attempt is made to correlate the strata with the Cape and Karoo systems; and for the present the author gives the following provisional classification:—

		Thickness in feet.
Taba 'Sinduna Series	Sandstones and volcanic rocks	200
Forest Sandstones		1000
Escarpment Grits		400
Upper Matobola Beds (fossiliferous).	Coal-measures	300
Busse Series (fossiliferous).	Sandstones and grits	300
Lower Matobola Beds	Coal-measures	200
Sijarira Series	Quartzites and current-bedded sandstones	2000

Great unconformity.

Basement-rocks: Gneiss, schists, and pegmatites of Mafungibusi and Lubu.

Fossils have been found in the Coal-measures, comprising mollusca, plant- and fish-remains, which are described in appendices. These indicate the age of these beds to be Permo-Carboniferous.

The Coal-measures yield coal of excellent quality, and the areas in which seams outcrop, or have been developed, are described under the names of the Mafungibusi, Sesami, Sengwe, Lubu, Sebungu, and Wankies Coalfields in the north, and the Tuli and Sabi Coalfields in the south.

Reference is made to the numerous mineral springs, of varying temperature, that are dotted along the Zambesi Valley, and to mounds of travertine, containing recent fresh-water and land shells, that have been accumulated by extinct springs.

Volcanic rocks are well displayed in a long area extending from Macloutsie to the Bubi River, 200 miles; and the extinct craters are still recognizable at Fort Tuli, which gives the name to this tract of Tuli Lavas. Sheets of basalt are interbedded with the Forest Sandstones at the Bubi and Gwampa Rivers; and at a portion of the escarpment above the Sesami Coalfield, basalt forms a capping and extends back about 24 miles.

Three appendices are added: one, on a New Species of *Acrolepis* from the Sengwe Coalfield, by A. Smith Woodward, LL.D., F.R.S., F.G.S.; a second, on some Lamellibranch Mollusca, by Wheelton Hind, M.D., F.R.C.S., F.G.S.; and a third, on some Fossil Plants from Rhodesia, by E. A. Newell Arber, M.A., F.G.S.

II.—February 4th, 1903.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Granite and Greisen of Cligga Head (West Cornwall)." By John Brooke Scrivenor, Esq., M.A., F.G.S.[1]

The small granite mass between St. Agnes and Perranporth has been described by Conybeare, Carne, Sedgwick, Foster, and others. It is a remnant of a much larger mass which has been partly denuded by marine action and partly hidden by a north-and-south fault. It is possible to distinguish two divisions of it; the main mass and the 'tongue,' throughout both of which 'bedding' is well developed. The granite bordering the bedding-planes has been altered into greisen, which, owing to the abundance of quartz, appears in the cliff-section as dark bands. Each greisen band contains a quartz-vein, marking the original fissure along which metasomatism took place; the veins contain tourmaline, cassiterite, wolfram, mispickel, and chalcopyrite. Two main reactions appear to have taken place in the formation of the greisen; the felspars affording topaz, muscovite, and secondary quartz; the biotite, brown tourmaline, magnetite, and secondary quartz. The fact that no tourmaline has been formed from the felspar, owing to the presence of abundant fluorine, distinguishes this greisen from luxullianite and trowlesworthite. The blue tourmaline prisms included in original quartz appear to have been original constituents of the granite. Secondary quartz, deposited in optical continuity with the original grains, has also caused them to appear to have a crystal outline. The fluorine and boron had not so great an effect on the extremity of the tongue as on the main mass, as shown by the poor development of greisen and the freshness of the biotite. Mica, topaz, and microcline-perthite have been redeposited there by percolating water or vapour. The greisen is an example of Professor Vogt's 'pneumatolytic' action in thoroughly acid rocks, resulting in the formation of tinstone lodes, as contrasted with the similar action in syenitic rocks with the production of zircon, etc., and in basic rocks with the production of chlor-apatite and the scapolitization of the felspar.

2. "Notes on the Geology of Patagonia." By John Brooke Scrivenor, Esq., M.A., F.G.S.

The author was travelling in Patagonia from September, 1900, until March, 1901. The sedimentary strata consist of Tertiary, Cretaceous, and Jurassic formations, which, with the exception of the Jurassic, yield interesting and varied faunas, both vertebrate and invertebrate. The latest classification is that drawn up by Mr. J. B. Hatcher, who conducted the expeditions sent from

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[1] Communicated by permission of the Director of H.M. Geological Society.

Princeton University. Mr. Hatcher, aided by Dr. Stanton and Dr. Ortmann, has arrived at the following correlation :—

Shingle Formation (Téhuelche Pebble-bed)	PLEISTOCENE.
Cape Fairweather Beds	PLIOCENE.
Santa Cruz Beds	UPPER MIOCENE.
Patagonian Beds	LOWER MIOCENE and UPPER OLIGOCENE.
Upper Lignites	MIDDLE OLIGOCENE.
Magellanian Beds	LOWER OLIGOCENE and UPPER EOCENE.
Guaranitic Beds	CRETACEOUS.
Lower Lignites	
Variegated Sandstones	
Upper Conglomerates	
Belgrano Beds	
Lower Conglomerates	
Gio Beds	
Mayer Shales	JURASSIC.

Except in the north, where intrusions of an acid type have disturbed the sediments, the southerly dip is so gentle as only to be appreciable where sections can be followed for some distance. Mr. Hatcher considers that an unconformity separates the Magellanian and Guaranitic Series, also the Cretaceous and Jurassic.

Excellent sections of the Patagonian Beds were seen on the Santa Cruz River and in the coast-section at Monte Leon. They are littoral deposits, consisting of sandstones and mudstones. Calcareous nodules are frequently arranged along the bedding-planes. Petrologically the sandstone is remarkable for containing fresh hypersthene and plagioclase. At Monte Leon the top of the Patagonian Beds is marked by gypseous mudstones and a shell-bed. These are succeeded by estuarine beds, some of which yield impressions of *Fagus*. Conformable on the estuarine beds are the famous Santa Cruz Beds, which have yielded a rich vertebrate fauna. They consist chiefly of pumiceous mudstones, with a little hypersthene; but a blue clay alternates with the mudstones, and there are also two bands of *Ostrea ingens*, and one or two of ferruginous sandstone. The Téhuelche Pebble-bed passes down into the Cape Fairweather Beds imperceptibly ; otherwise it overlies everything unconformably.

Very little is known of the igneous rocks. Apart from those of the Cordillera, there are vast plateaux of basalt and intrusions of quartz-porphyry. A good example of the latter occurs at Port St. Helena. The specimens of igneous rocks collected from the moraines of the Cordillera comprise biotite-granite, hornblende-granite, quartz-mica-diorite, gabbro, hornblende-picrite, quartz-porphyry, rhyolite, obsidian, ophitic olivine-dolerites, olivine-basalts, and acid tuffs.

The basalt-flows cover an enormous area. They slope gently towards the Atlantic, and are cut off from the Cordillera by a longitudinal depression. In the neighbourhood of Lago Colhuapé there seems to have been a distinct centre of eruption, apart from that which commences nearer the Cordillera. All that can be said of their age is that they are older than the transverse depressions of the Cordillera, and older than the glaciation of the eastern slopes of that chain.

The Téhuelche Pebble-bed, which covers nearly the whole of Patagonia, has been ascribed to marine action by some authors, by others to glacial action. A third suggestion is the agency of big rivers. No one of these agents alone could have produced the observed phenomena; the origin was complex. The bulk of the material was brought by glaciers from the Cordilleras to the sea, which then covered the greater part of the pampas. As the sea receded, it distributed the pebbles over the bottom, so forming a continuous layer, such as now exists between the eastern coast and the Falkland Islands. Torrents resulting from the melting of the glaciers assisted in distributing the material from the Cordillera. Part of the material on the present eastern coast was derived from islets of quartz-porphyry in the Pleistocene sea. A great difficulty is that no basalt-pebbles are found at Santa Cruz east of the flows.

The drainage system includes several eastward-flowing rivers and numerous lakes, some of which occupy transverse valleys cutting through the Cordillera. An example of the latter is Lago Buenos Aires. The history of this lake can be gathered from the evidence observed on its shores. Lagos Musters and Colhuapé are two other interesting lakes near the eastern coast. The width and depth of the river-valleys are disproportionate to the present streams; this can be explained by a decreasing rainfall, and also by the diversion of many tributaries to the Pacific. Some valleys are dry, as, for example, the Great Cañadon Salado.

3. "On a Fossiliferous Band at the Top of the Lower Greensand near Leighton Buzzard (Bedfordshire)." By George William Lamplugh, Esq., F.G.S., and John Francis Walker, M.A., F.L.S., F.G.S.

This paper describes a newly discovered fossiliferous band at the top of the Lower Greensand, overlain by the Gault, in the sand-pits at Shenley Hill, near Leighton Buzzard, in Bedfordshire. The fossils of this band present a different facies from that of any other previously known fossiliferous horizon of the Lower Greensand, and show closer affinities with the fauna of the Upper Greensand than have hitherto been recognized in any deposit below the Gault. The Brachiopoda are closely allied to those contained in the Tourtia Beds of Belgium. The fossiliferous bed is rather sharply marked off from the underlying unfossiliferous 'silver-sands,' but is still more sharply marked off from the overlying Gault. Stratigraphically it forms part of the Lower Greensand, and cannot (without violence to the accepted classification of the deposits) be considered to belong to the Gault. The fossils constitute the newest Lower Cretaceous fauna as yet recognized in England. Several species, hitherto supposed to be confined to the Selbornian, are now shown to have been in existence before the deposition of the Gault. The lithological characters of the bed indicate a sea-bottom of moderate depth, swept by powerful currents, and the conditions were thus similar to those which persisted in the neighbourhood throughout Lower Greensand times. The overlying Gault shows a change to more tranquil waters, probably of greater depth.

CORRESPONDENCE.

QUARTZ DYKES NEAR FOXDALE.

SIR,—Though I have not visited Foxdale in the Isle of Man, I venture to express a doubt whether Mr. Lomas (p. 34) has succeeded in proving its quartz dykes to be igneous rocks. 'Dykes' and veins of that mineral are common in many countries, and cut almost all kinds of rock, though, as might be expected, they are rather rare in the more igneous or basic limestones. Sometimes the dykes attain a considerable thickness and may be traced for a long distance; at others veins run off into the finest threads, and their demeanour is unlike that of an igneous rock, from which they are often far away, and their abundant fluid cavities and consequent whiteness (as described by Mr. Lomas) suggest that they have been formed from water. That silica, both crystalline and colloid, is so deposited, especially from hot springs, is well known (see, for instance, a very important paper by the late Mr. J. A. Phillips, published in the Quarterly Journal of the Geological Society, vol. xxxv, p. 390). The fact that at Foxdale quartz veins traverse the granite in itself suggests they are later in origin and formed by thermal waters, with which their occasional relation to dykes of microgranite is quite consistent. Mr. Lomas appears to regard the fact that the veins on entering the granite change locally into pegmatite as strongly in favour of his hypothesis. But the presence of felspar or even mica in a vein does not prove it to have had an igneous origin. I have examined numbers of quartz-felspar-mica veins in gneissoid rocks which seemed to differ in important respects from granite. Sometimes, though by no means always, they have been affected by the pressures which have produced the schistose structure; but the three minerals are usually associated in a clotted and irregular fashion, very different from that characteristic of rocks which have solidified from a molten condition, and their structure frequently is abnormally coarse, even in comparatively thin veins, where a true igneous rock would be almost invariably either compact or not more than microgranular. The most remarkable case of mineral grouping which I have seen was in the neighbourhood of Svolvaer in the Lofoten Islands. Here a coarse gneissoid rock was cut by a quartz vein, varying irregularly in breadth from two or three feet to as many yards. By its side, and in places mixed with it, were a fairly broad band of felspar and a much narrower one of a dark ferromagnesian mineral, which at the time, more than thirty years ago, I took for a pyroxene. The quartz was white and curiously divided by sharp joints into parallelepipeds, rather variable in size. If, then, this was an igneous vein, there must have been three distinct ejections (only locally mixing) of quartz, felspar, and a ferromagnesian mineral (not necessarily in the order of enumeration). The pegmatite of the Foxdale vein, according to Mr. Lomas, contains felspars, some over three inches long, perfectly formed, and showing crystal faces. But the latter habit (except when there is considerable difference between the fusion point of a mineral and the residual magma) is far more indicative of formation by water, and is not usual in pegmatites, so far as I know them; if, indeed, all these are igneous rocks. Mr. Lomas, however, may reply that he does not assert all quartz veins, even if including felspar and mica, to be igneous, but only that at Foxdale. But if so, we may fairly ask him to tell us how to distinguish igneous from aqueous veins. The former, when they cut through sedimentary rock, especially if it be argillaceous, generally produce rather conspicuous structural and mineral changes, so that here I expected Mr. Lomas to give a careful description of the contact-metamorphism or to offer an explanation of its absence. Instead of this I find only the vague phrase 'altered slate'—a phrase compatible with slight silicification or other changes such as may take place by ordinary infiltration, and thus be no help to his hypothesis. I do not deny that differentiation might possibly be carried so far in an ordinary acid magma as to leave a residuum of pure or nearly pure silica (though I have never met with an instance of it), but I think it more probable that, as Mr. Lomas substitutes at critical points vague phrases and inconsequent statements for precise description, he has yielded to the fascination of a novel hypothesis.

P.S.—The above was written before the publication of Mr. Harker's letter (p. 95). T. G. Bonney.

THE ORIGIN OF QUARTZ-VEINS.

Sir,—In connection with the question of the origin of certain quartz-veins,[1] the fact that quartz reveals plastic qualities at temperatures considerably below the melting-points of many undoubted igneous minerals must be born in mind. J. Joly.

Trinity College, Dublin.
February 9th, 1903.

NEW GEOLOGICAL TERMS AND FALSE ETYMOLOGY.

Sir,—As no one seems inclined to protest against the terms 'calcrete' and 'silcrete' with which Mr. Lamplugh proposes (in your December number[2]) to disfigure geological nomenclature, I must even raise a voice in the desert. Brief expressions for what he intends them to convey would doubtless be useful, and no one would be likely to quarrel with 'calcicrete' and 'silicicrete,' of which one would be two, the other three, letters longer. I admit that public convenience may sometimes prevail over strict etymological rules, as in preferring the inaccurate 'telegram' to 'telegrapheme'; but 'calcrete' and 'silcrete' are even worse than the fashionable mongrel 'peneplain,' and approximate in malformation to the hideous 'phenocryst,' which seems invented to signalize the divorce of geology from culture. T. G. Bonney.

THE DEHYDRATION OF LATERITE.

Sir,—The very interesting paper on "The Constitution of Laterite," by Mr. T. H. Holland, appearing in your issue for February, 1903, raises several questions of chemical physics which are of the utmost importance from a geological standpoint. That crystalline affinity is a definite molecular force accompanied by exothermic changes is doubtless correct, but whether this force can determine chemical changes of an endothermic character is a question involving an entirely new conception, and requires careful consideration before it can be accepted as a reasonable hypothesis. More especially is this the case when we have to deal with the constitution of hydrates, which afford such excellent examples of the application of the phase rule in chemical physics. Hydrates, as is well known, have a vapour pressure of their own, and only continue to exist when in equilibrium with the vapour pressure which they have to support. Thus the hydrates of copper sulphate can be successively decomposed under varying conditions of temperature or pressure. The instability of the aluminium hydrate, $Al_2O_3 . 3 H_2O$, at moderate temperatures, also, is a fact well known in chemistry; and it seems probable that the occurrence of any hydrate, either of aluminium or of iron, in nature will depend upon which happens to be the stable phase under the existing conditions of temperature and pressure.

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[1] See Mr. J. Lomas's article, Geological Magazine, January Number, p. 34, and Mr. Alfred Harker's letter, February Number, p. 95.

[2] Geol. Mag., December, 1902, p. 575.

In connection with the crystallization of alumina the researches of W. Spring, of Liège, appear to have some bearing. According to this observer, amorphous alumina or ferric oxide, if damp, can be rendered compact, presumably with the occurrence of an incipient crystallization, by pressure alone; and we are induced to consider whether the amorphous state in solids may not, in some cases at least, be comparable with the condition of superfused solutions and glasses. In fact, many of the distinctions between solids and liquids are gradually breaking down under the researches of modern physics.

There does not, therefore, appear to be any necessity for a new theory to explain the facts in this case. It appears rather that Mr. Holland has unnecessarily introduced a difficulty by presupposing that the molecules in laterite are isolated from extraneous energy. If this were really the case there could be no change of entropy such as he describes, and rightly, to be the result of the reactions involved.

J. VINCENT ELSDEN.

38, ST. STEPHEN'S GARDENS, TWICKENHAM.

THE COLOUR OF GLASLYN AND OF LLYN LLYDAW.

SIR,—Glaslyn and Llydaw are the names of the two chief Snowdonian tarns. Glaslyn has been noted from time immemorial for the greenish colour of its water, as is implied by its name; but until the Summer of 1899 there was nothing peculiar about the colour of Llydaw. During that Summer, however, for the first time within the last fifty years at least, the water of Llyn Llydaw became as green as that of Glaslyn. The cause of this remarkable change of colour is not far to seek; for in the Spring of 1899, some time about March I am told, the company that works the Snowdon Copper Mine commenced crushing and washing their ore on the [illegible]k of Llydaw, so that a large quantity of greenish débris was and is daily carried into the lake, whose water has thus become turbid and greenish in colour. The rock excavated along the copper veins is of a greenish colour, as may be seen by looking at the tips from the adit-levels.

This change of colour in Llydaw explains the colour of Glaslyn, about the cause of which there has hitherto been some doubt. For it cannot now be doubted that Glaslyn owes its green colour to the detritus of green rock washed into it from the adit-levels of the mines. J. R. Dakyns.

P.S.—I should say that the mines are situated immediately above Glaslyn.

Snowdon View, Nant Gwynant, Beddgelert.
January 21*st*, 1903.

THE TERM 'HEMERA.'

Sir,—Mr. Buckman appears to think that stratigraphy is nothing but geological chronology i.e., that it is chiefly concerned with the days and weeks of geological time, and that the actual sequence of rocks is of less importance.

He will not admit that his definitions of the term hemera, or his correlation-table of zones and hemeræ in Quart. Journ. Geol. Soc., vol. xlix, p. 519, are open to misconstruction, and yet he complains that most of those who have essayed to use his term have misunderstood the meaning he intended to give it. It now appears that in that table he was giving us a geological calendar, and not an ordinary correlation-table of rock-subdivisions.

The real fact is that Mr. Buckman gave a name to an abstract idea relating to a thing which had no definite name at the time when he wrote. His paper was a stratigraphical one, and he cannot deny that he was actually dealing with the subdivisions of zones, yet, instead of proposing a name for the small subdivisions which he recognized in the sequence of deposits, he gave a name to the time occupied in the formation of each subdivision; in other words, he saw no necessity to give a name to the thing itself, but only to the geological day or week in which it was formed.

He asserts that he was giving a name to the duration of a zone, but this assertion is inconsistent with his original definition of a hemera; he says, "successive hemeræ should mark the smallest consecutive divisions which the sequence of different species enables us to separate in the maximum developments of strata." Now, a zone is not the smallest possible subdivision of a series of beds, and Mr. Buckman's own tables show that he knew it was not, for they show that it took the time of two or three hemeræ to form one zone. Hence, if a hemera is anything at all it is not the duration of a zone, but of some subdivision of a zone.

The only point that Mr. Buckman has made quite clear is, that he will not have his term 'hemera' used as the name of a rock-division, but he has not clearly indicated with what recognized subdivision of a stage he wishes the term to be connected. If he makes any reply to this letter, let him state clearly whether he accepts the term subzone, and whether he intends the word hemera to denote the duration of a subzone. If he does, then I can safely promise that he shall not in future be annoyed by my misuse of the term, for I will take care never to use it except on those infrequent occasions when I want to express the time during which a certain subzone was formed. My chief concern is with the actual stratigraphical unit and the fossils which it contains; a name for the time-unit may be convenient, but is of quite secondary importance. Hence his *reductio ad absurdum* does not trouble me. A. J. Jukes-Browne.

Torquay, *February 4th*, 1903.

OBITUARY.

HENRY STOPES.

Born February 17, 1852. Died December 5, 1902.

We regret to record the death, on December 5th, 1902, of Mr. Henry Stopes, for many years a Fellow of the Geological Society of London. He was born at Colchester on Feb. 17th, 1852, and it was perhaps his early association with that ancient place which turned his thoughts to antiquities. When a boy of 8 he found a fossil *Echinus* in the playground gravel, and after seeking in vain from all he met an explanation of its peculiarities, he took it to bed with him, that he might meditate at leisure in the morning over its meaning. For this he was punished, but the punishment only intensified his interest, and he kept that stone, which became the nucleus of a large geological collection. He early brought together a fine series of Essex Crag shells, part of which is now on loan at the Stratford Museum. While collecting this, he received from a friend, a fellow-collector, a specimen of *Pectunculus glycimeris*, which the latter had himself taken from the Red Crag at Walton-on-the-Naze, with a rude carving of a human face on it. Mr. Stopes read a short note on this at the British Association Meeting at York, 1881 (see Report, p. 700). The carving has not been generally accepted as conclusive by all geologists and anthropologists in England, but some French anthropologists have done so. It is mentioned in Keane's "Ethnology," p. 78. Mr. Stopes considered that the carving suggested pre-Glacial man;[1] he was the first to set to work to disprove or verify it, and it thus determined the direction of his later researches. He took a house near the gravel-pits of Swanscombe, where he made many interesting discoveries, notably that of the association of Palæolithic implements in a sand-bed there with *Neritina fluviatilis* and other extinct species of shells (see his paper in the Journ. Anthrop. Inst., xxix, p. 302). He has collected an enormous number of stone tools, chiefly Palæolithic. His first paper on "The Salting Mounds of Essex" was read before the Essex Antiquarian Society, Dec. 20th, 1884, and was published in the *Essex Naturalist*, April and May, 1887. He read many papers before the Anthropological Section of the British Association and several before various Geological and Literary Societies.

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[1] [It must be borne in mind that the drawing on the shell from the Crag of Essex is open to the same objection as is the cut bone of a Cetacean from an Italian Tertiary deposit, also attributed to man's handwork, namely, that *both deposits are marine*.—Edit.]

He wrote some articles and reviews for the *Athenæum* and other Journals. His enthusiasm kindled interest in his researches among all he met, friends or workmen alike. When the complaint from which he suffered was found to be consumption, he was ordered to try open-air treatment, and he would go nowhere else than to the scene of his researches. He was buried near Old Swanscombe Church on December 10th, and the workmen of the village feel they have lost a friend.

ALFRED VAUGHAN JENNINGS,

Assoc. R. S. Mines, F.L.S., F.G.S.

Born April 17, 1864. Died January 11, 1903.

Alfred Vaughan Jennings was born at Hampstead, and educated at St. Paul's School. He matriculated at London University 1877, and entered as a student at the Royal School of Mines under Professor Huxley, etc., where he was bracketed first in Advanced Zoology with Martin F. Woodward in 1885, and received the Edward Forbes Medal and prize of books for Biology in that year. He was for three years Demonstrator in Geology with Professor Judd, F.R.S., undertaking at the same time to instruct privately, in his own laboratory in Chancery Lane, a class of students in Biology, preparing for the B.Sc. London University Examination. He also taught occasional classes in Botany at the Birkbeck Institution.

It was the passionate earnestness with which he taught and inspired these young men which first betrayed his abnormally nervous temperament and weak heart. The work of teaching, for which he inherited a genius, had in consequence to be given up. Six months were then spent beneficially in a voyage and visit to New Zealand. On his return in 1890 he undertook the arrangement of the new Museum about to be opened at Eton College; and after the death of Dr. P. Herbert Carpenter he was offered by Dr. Warre, Head Master of Eton College, one of Dr. Carpenter's classes, in addition to the permanent care of the Museum. This he was compelled to decline, as the doctors still forbad his teaching, and residence at Eton had already proved mischievous to his health.

In 1892 he took charge of the Museum then opened at Whitechapel. In 1895 he removed to Dublin, where for three or four years he assisted Professors Cole and Johnson with the geological and botanical classes at the Royal College of Science. But teaching had again to be abandoned. He subsequently went to Davos Platz, and later to Bad Nauheim, from which places he sent papers to the Geological Society and to this Magazine, viz.:—

Jennings, A. V.—"On the Courses of the Landwasser and the Landquart": Geol. Mag., 1899, pp. 259–270, with three illustrations.

——— "The Geology of the Davos District": Proc. Geol. Soc., May 10, 1899; Geol. Mag., 1899, pp. 326–327; Quart. Journ. Geol. Soc., 1899, vol. lv, pp. 381–412, pls. xxvi and xxvii, map, and section.

——— "The Geology of Bad Nauheim and its Thermal Salt-Springs": Geol. Mag., 1900, pp. 349–366, with six illustrations.

His last year was spent mostly in Christiania, where, in spite of much physical suffering—caused by a tramcar collision, which confined him to hospital for some time—he was working to the end.[1]

MISCELLANEOUS.

THE NEW DIRECTOR OF THE GEOLOGICAL SURVEY OF INDIA.—Mr. C. L. Griesbach, C.I.E., F.G.S., who has filled with distinction the office of Director of the Indian Geological Survey in Calcutta since the resignation of Mr. King on 17th July, 1894, retired under the age limit on December 11th, 1902, and we learn with much pleasure that Mr. T. H. Holland, Assoc. R.C.S., F.G.S., has just been appointed to succeed him. Only in our February Number, Mr. Holland contributed what may be without exaggeration described as an epoch-making article "On the Constitution, Origin, and Dehydration of Laterite," which is already attracting the earnest attention of Indian and other geologists in this country.

Thomas H. Holland received his scientific training in the Royal College of Science, South Kensington, between 1885 and 1888. He passed his examination as associate with honours, and was awarded the Murchison Medal of the Royal College of Science in 1887.

Mr. Holland joined the Geological Survey of India in 1890, and was appointed Professor of Geology and Mineralogy at the Presidency College, Calcutta, in 1893. He has already contributed numerous papers of high scientific value to the Records and Memoirs of the Geological Survey of India, the Royal Asiatic Society, Calcutta, the Mineralogical Magazine, the Geological Magazine, and the Quarterly Journal of the Geological Society of London.

Mr. Holland has shown himself to be an acute and accurate observer, both in the laboratory and in the field, and his contributions to Mineralogy and Petrology contain careful work of a very high order. His memoir on the Charnockite Series is a classical contribution to the study of the Archæan rocks of Southern India.

His papers on the igneous eruptive rocks of Salem at Canoor and the elæolite-syenites of Coimbator are also valuable contributions which have added greatly to our knowledge of the crystalline rocks of Peninsular India.

Mr. Holland has been selected at the early age of 34 to fill the important office of Director of the Geological Survey of India.

We congratulate him on his promotion, and Government on having obtained an energetic and reliable officer of such high promise to fill this important post. Mr. Holland has our best wishes for the success of his future career.

ERRATUM: p. 94, last line but one, for Professor *G. B. Fletcher* read *J. B. Hatcher.*

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[1] He wrote to the Editor at Christmas, offering him an article for the GEOLOGICAL MAGAZINE on the Geology of the Christiania district.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. IV.—APRIL, 1903.

ORIGINAL ARTICLES.

I.—The Development of River Meanders.

By Professor W. M. Davis, Harvard University, Cambridge, Mass.

THE paper by Dr. Callaway, "On a Cause of River Curves," in the Geological Magazine for October, 1902, suggests comment for two reasons: first, because the cause that he brings forward seems of doubtful application; second, because the habitual entrance of branch streams at a certain part of the curves of main streams is satisfactorily explained by controls which seem to be of surer and more powerful application than the control which he advocates.

In ascribing to a tributary the power to make a main stream bend in a definite manner towards the tributary, and thus determine the habitual entrance of tributaries on the convex side of the main stream's curves, Dr. Callaway argues that the detritus brought by the tributary will be deposited on the further side of the main stream and somewhat below the tributary's mouth. Various examples known to me of the deposits formed by side streams in the channels of main streams do not bear out this conclusion: the detritus is not deposited on the further side of the main stream, but as a delta at the mouth of the tributary or a little below it; and the main stream does not bend toward, but away from the tributary. The Rhine, the Colorado, and many other rivers that might be instanced, show abundant examples of this kind. Moreover, the assumption of an initially straight main river, as stated by Dr. Callaway, involves an extreme improbability. Rivers cannot be habitually straight in their initial stage, and the bends with which they begin are as a rule spontaneously exaggerated in their later development. The processes by which the initial bends are developed into meanders, and by which the meanders are persistently maintained when once developed—entirely independently of the action of tributaries,—are too important to be omitted from the problem in hand: above all, they should not be replaced by a doubtful or at most a weak process.

The most important process in the development of river meanders is the displacement of the line of fastest current by inertia from mid-channel toward the outside of every curve. As a result erosion tends to take place on the outside and deposition on the inside of the curve. This process is self-perpetuating. However slight the initial bends, they will be increased; and as the valley floor is broadened the curves will be developed into systematic meanders of increasing radius and breadth, as in Fig. 1. The only conditions under which the river course will tend to straighten itself are: strong tilting in the direction of river flow, and downward erosion upon a weak stratum between two resistant strata in an inclined structure. Both these conditions are only temporary; for as grade is reached in either case and the valley floor is widened, the residual departures from a perfectly rectilinear course will be exaggerated again, and in advanced maturity the river must always be curved. The smaller the stream, the greater the effect of accidental causes, such as falling sods and trees, tributary deltas, etc., in forming new bends. The larger the river, the greater the effect of inertia in exaggerating pre-existant bends and in overcoming local or accidental irregularities.

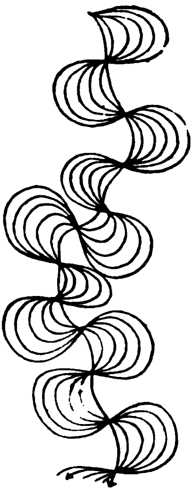

Fig. 1.

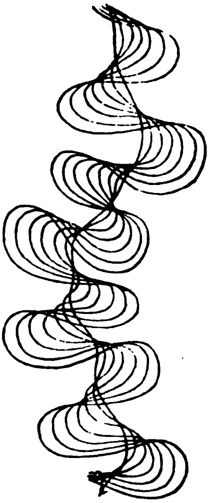

Fig. 2.

A river not only tends to increase its meanders; it also tends to push the whole meander system down the valley. This is because the line of fastest current, displaced toward the outside of each curve, enters the succeeding curve (or stretch between two curves) near the down-valley bank, which is therefore worn away, while the opposite up-valley bank is built out. As a result, Fig. 1 should be modified by a persistent down-valley migration of every bend, as in Fig. 2. Cut-offs occur now and then, here and there, but the shortened course at a cut-off is not straight, and its faint curves are soon systematically exaggerated into meanders again. Abundant verification can be given of this scheme of development, by observing the behaviour of actual rivers, or more simply by studying the new edition (1900–1901) of the preliminary maps published by the Mississippi River Commission at St. Louis, Missouri, on which the river channels as determined by surveys in 1893–5 are over-printed in red upon the results of surveys in 1881–3, printed in black.

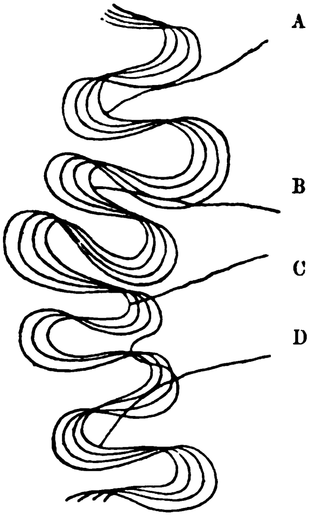

Fig. 3.

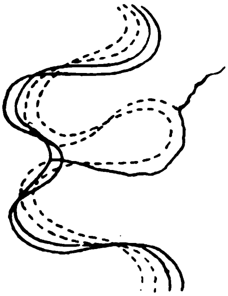

Fig. 4.

Any river that we now see meandering in an open alluvial plain must have been meandering a long time. Its individual meander curves must have already advanced down the valley over considerable distances; and it is, I believe, chiefly for this reason that tributaries are taken in where the main stream bends toward them. To make this clear, let a number of tributaries be added at random to the latest river course, drawn in Fig. 2. Four of them are shown in Fig. 3: one enters the river at a convex bend, the other three at or near concave bends. Now let the normal changes of the meanders continue still farther, as in the dotted lines of Fig. 4. In the first of these changes, tributary D is taken in by the convex curve next above the concave curve that it entered before. In the second change, the mouth of the tributary B is similarly transferred to a convex curve. In the third change, the same fate overtakes tributary A. During all these changes, tributary C has been only a little shortened; it still enters on a convex curve. When this curve comes to move down the valley the tributary will prolong its course, but will continue to enter the main stream on the up-valley side of a curve, until it is captured by the approach of the next following curve. It therefore appears natural enough that tributaries should usually enter the main river meandering freely on a flood plain where its curves turn toward them.

The simplest conditions under which a tributary should be led to enter its master at an abnormal point are found in the occurrence of a cut-off, as in Fig. 4; but this special case would soon be brought under the rule, either by the development of a new meander which will usually grow towards the tributary in the neighbourhood of the cut-off,[1] or by the approach of the next up-valley meander.

A second group of examples would include rivers that follow relatively narrow meandering valleys, like those of the lower Wye, the lower Seine, the lower Moselle, or the north branch of the Susquehanna. Here the same rule may be expected to apply to the entrance of the tributaries, and that for two reasons. In the first place, because such rivers have, it may be said with much confidence, incised their meandering valleys from a meandering course that they formerly possessed on the upland in which the valleys are incised, when that upland was a lowland of erosion. On such a lowland the rivers must have reached a late stage of their cycle of development, and in a late stage they must have been meandering freely. While the uplift was going on and afterwards, the meanders would have been incised beneath the uplifted lowland; but the entrance of the tributaries has not been thereby significantly altered from whatever orderly arrangement they had gained during the former lowland stage of erosion.

In the second place, if by chance any abnormally entering tributary existed when uplift and incision began, the normal processes of widening the meander belt and of shifting the meanders down-valley, which must accompany incision, would sooner or later bring about a normal entrance in the same manner as on an alluvial flood plain, shown on Fig. 3, but at a lower rate than there obtains. An excellent instance of this kind is known in the lower Seine, where the Ste. Austreberte has been taken in at Duclair, not far below Rouen, precisely as illustrated in Fig. 3.

Another instance of the same kind occurs on the Marne not far east of Paris (see "The Seine, the Meuse, and the Moselle," Nat. Geogr. Mag., 1896, vii, 191). The Moselle exhibits at least one illustration of the entrance from the south-east of a small tributary, the Veldenzer Bach, on a concave stretch a short distance up-stream from Berncastel; but this is demonstrably the result of a cut-off, as shown in Fig. 4 (ibid., pl. xxii, opp. p. 193).

These normal, effective, and fully verified habits of change in the course of a meandering river seem to account very fully for the rule that tributaries usually enter where the river curves toward them; a rule that Mr. Callaway shows to obtain for various rivers in many parts of the world, and that is supported by certain additional examples that I have recently inspected.

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[1] The changes following the occurrence of a cut-off, as illustrated on the maps of the Mississippi, show that the growth of a new meander towards the cut-off and abandoned meander, but a little further down-valley, is not unusual.

II.—CREECHBARROW IN PURBECK.—No. 2.[1]

By W. H. HUDLESTON, M.A., F.R.S., F.G.S.

ADDITIONAL POINTS IN STRATIGRAPHY.

In my paper published in the Proceedings of the Dorset Field Club (vol. xxiii), I dwelt at some length on certain borehole sections made towards the northern base of Creechbarrow with a view to the discovery of Pipeclay. This course was adopted in the hope that a study of these sections might throw some light on the stratigraphical relations between the Creechbarrow Beds on the hilltop and the Pipeclays lower down, if indeed there are any stratigraphical relations beyond a mere jumble of irregular deposits whose precise orientation can never be disentangled. Whether this latter supposition is the true one or not, the exceptional character of the Creechbarrow Beds, as a local feature, remains the same, even although we cannot decide whether they go under, over, or into the Pipeclay series. Before attempting any further speculation as to the possible stratigraphy of the region I will call attention, at any rate, to its topography as shown in the accompanying figure.

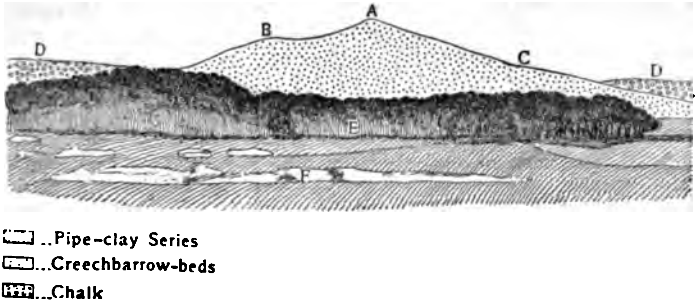

FIG. 1.—Creechbarrow from the north-east, based on a photograph by the late Mr. Laurence Pike.

A. Summit of Creechbarrow, 637 feet.
B. The eastern spur.
C. The northern ridge (approximate dip slope). The hilltop limestone extends along this ridge as far as the 500 feet contour.
D D. The Purbeck Hill; maximum elevation 654 feet, just behind Creechbarrow.
E. Blackhills Plantation, about the 300 feet contour.
F. Spoil-heaps of the clay workings.

North-East Side of Creechbarrow: Additional Particulars as to the Creechbarrow Beds.—From the above figure the *topographical* relations of the Creechbarrow Beds to the Pipeclay series can be seen at a glance; the former looks down upon the latter. It is scarcely necessary to point out that the Purbeck Hill (D D), consisting of Chalk, is depressed by perspective, the highest part of it slightly exceeding the height of Creechbarrow. A word as to the composition of the Creechbarrow Beds seen in this figure may be useful as a sort of recapitulation of what has already been stated. If I give this in the form of a generalized vertical section, it is merely for the sake of convenience, and not to be regarded as absolutely true at any one point.

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[1] No. 1 appeared in the June number of the GEOLOGICAL MAGAZINE for 1902. It was then intimated that the subject would be treated more fully in the Proceedings of the Dorset Field Club. This has been done, and a portion of the additional matter is now, by the kind permission of the Publication Committee of the Dorset Field Club, reproduced in the GEOLOGICAL MAGAZINE. This portion relates mainly to the lithology and palaeontology of the Creechbarrow Beds.—W. H. H.

Plate XI, illustrating this paper, will appear in the May number with the remaining part of the article.—EDIT. GEOL. MAG.

1. The highest bed of the series is the deposit on the Creechbarrow Limestone. With this must be associated the beds above the 'marl' detailed in the northern section. The thickness of these latter beds is about 13 feet down to the 'main marl,' and they consist of sands, clays, flints, and a thin bed of 'marl.'

2. The next in downward succession is the hilltop, or Creechbarrow Limestone, which is excessively hard at the summit (A), but becomes softer when traced on the dip slope towards the 500 feet contour (the letter C is approximate); in this condition it is known as 'marl,' and may be about 12 feet thick in some places.

3. The beds immediately *below* the Creechbarrow Limestone are extremely variable, and constitute a stratigraphical crux of considerable perplexity. They certainly differ materially within short distances, and but little analogy can be traced between those on the south side of the summit and those on the north side, which are below the 500 feet contour. On the south side of the summit these beds have been traced in detail with considerable accuracy for about 20 feet vertical, and this must be regarded as the standard section.

On the whole, we may sum up by stating that the beds immediately below the summit Limestone, for a vertical extent of perhaps 30 feet or more, are sandy, with some yellow clay, frequently manganiferous, and are characterized by numerous beds of flints, the beds ranging from 6 inches to 3 feet 6 inches in thickness; loose flints also occur in the sands.

In further illustration of this class of beds I would direct attention to the eastern spur of Creechbarrow (B of Fig. 1). This spur is a conspicuous object from the north-east side, since it breaks the regularity of the conical outline as seen from Furzebrook.

Being desirous of finding some evidence as to the cause of this slight local prominence, I had a special pit sunk on the very top of it, with the following result:—

PIT ON THE EASTERN SPUR OF CREECHBARROW.	ft.	in.
a. Sandy earth with flints	0	6
b. Flint-gravel	3	6
c. Buff, ferruginous sand with manganese nodules	2	6
Total section	6	6

The flint-gravel (*b*) of this section is the thickest deposit of the peculiar 'gravel' of Tertiary age as yet discovered on Creechbarrow; water was lying in the bottom of the pit, apparently due to a pan formed by surface action. The extent of the opening scarcely permitted us to ascertain whether there is any bedding in the 'gravel.' The stones are of very unequal size, varying from flints 30 lb. in weight to quite small stones; I did not at the time notice any pebbles. The character of the flints here is just the same as in all the Creechbarrow Beds; the large ones have a partially rounded exterior consisting of white silica thoroughly degelatinized. Some are degelatinized throughout, others have a brown core of gelatinous silica still left; most of them are very brittle and fly to pieces on being struck by the hammer. At present it is not possible to connect this particular bed of flints with those found in the pits near the summit. That there are beds of flints occurring in stratigraphical relation to the sands and clays of this hill is certain, and they probably occur on several horizons. The manganese nodules in the buff, ferruginous sand are very interesting and fairly abundant. I shall refer to them again when dealing with the lithology of the Creechbarrow Beds.

The evidence obtained in this pit on the eastern spur goes to confirm the supposition that the abundance of bedded flints of Tertiary age in the upper part of Creechbarrow has materially assisted the limestone in preserving the softer sands and clays from denudation. Such an observation may be accepted as a general one, applicable more or less to the whole hill. When we come to particulars the limestone is more especially accountable for the summit (A), whilst the unusual accumulation of flint 'gravel' is more directly the cause of the eastern spur (B).

3′. *The Buff-coloured Clay.*—Still dealing with the deposits immediately below the limestone and 'marl,' we have seen that, on the northern slope and some distance below the 500 feet contour, the calcareous series rest on a few feet of sands with flint-gravel, and that below this comes a very important deposit of buff-coloured clay (Mr. Bond's clay-pit), which may occur as a lenticular mass, as it does not appear to have any representative if followed in the direction of the eastern spur.

4. The lowest member of what I have termed the Creechbarrow Beds are the 'Sands' underlying the buff-coloured clay. These can be studied at Mr. Bond's sandpit, where the following section may be noted:—

CREECH SANDPIT.

		ft.	in.
a.	Clay with rootlets	1	6
b.	Clay passing into sands; flints occur, especially towards the base (? unconformity)	5	6
c.	Bedded sand	1	3
d.	Yellow clay with large flints at base and a pink line ...	1	0
e.	Yellow variegated sandy clay with a few small flints ...	1	6
f.	Salmon-coloured sand with a black centre line, the coloration probably due to manganese	0	3
g.	Very fine white sand with but little true bedding (not bottomed)	9	0
		20	0

N.B.—*a* and *b* represent the base of the Creech brickearth or buff clay.

This concludes the description of the Creechbarrow Beds as far as I have been able at present to trace them. If we turn to Fig. 1 we perceive that the convenient obscurity afforded by the Blackhills Plantation helps to conceal their possible relation to the Pipeclay series; all we can say is that, topographically speaking, they occupy the higher ground, and that when we get well below the 300 feet contour the Pipeclay series has possession of the surface.

LITHOLOGY AND PALÆONTOLOGY.

The big Flints.—Before entering upon a detailed description of the Creechbarrow Limestone, there are some other matters of interest which may be considered. The first of these refers to the very large flints which have contributed in no small degree to the maintenance of the fabric of Creechbarrow, and which are such an exceptional feature in the Bagshot beds of this immediate district: their stratigraphical relations may be gathered from the preceding pages. As regards the general character and appearance of these flints, they are for the most part of a dirty cream-colour; they are also much degelatinized, and in some cases the exterior is simply a mass of granular silica, very meagre to the touch. They are also extremely brittle when first dug out, though it is probable that exposure to the atmosphere toughens them after a while. In consequence of this brittleness the available fragments do not much exceed 28 lb. in weight, so far as I have seen them, though it may well be that heavier flints than these occur. These flints have split in the bed itself. The surface of those flints which are not much broken has been subject to very little modification from abrasion. Associated with the big flints are flint pebbles and other stones of moderate size, also quartzose grit.

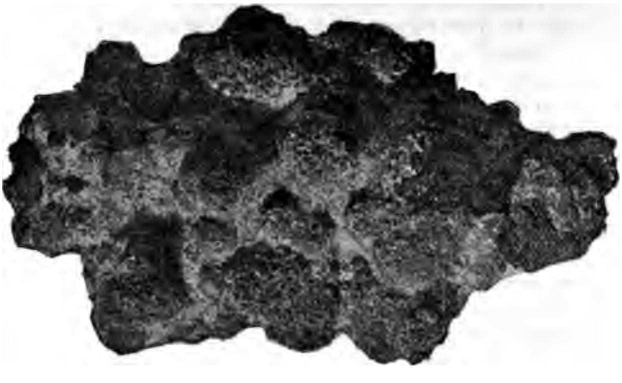

FIG. 2.—One of the manganese nodules from the eastern spur of Creechbarrow. Reduced ⅔ (from a photograph).

The peculiar fawn colour of these siliceous masses will help *to distinguish* them from ordinary plateau-gravel or valley-gravel flints; and the amount of soft and almost pulverulent material which coats so many of them is a further distinction, as this substance could never endure the wear and tear of the gravel-making processes. Without illustration, which would necessitate the employment of colour, it is by no means easy to convey an adequate idea of the peculiarities of the big flints, when freshly dug out of the beds which contain them. Their general appearance leads one to suppose that they had been subject to some corrosive action, and this is especially noticeable where there are any indications which may have been due to organic bodies, such as urchins or sponges.

When these Creechbarrow flints have been rolled down the hillside, and subjected to atmospheric action, the external coating of loose silica is found to have been entirely removed, and the flint itself bleached to a dirty white condition, though the casts of Pectens and other fossils still retain traces of iron-discoloration.

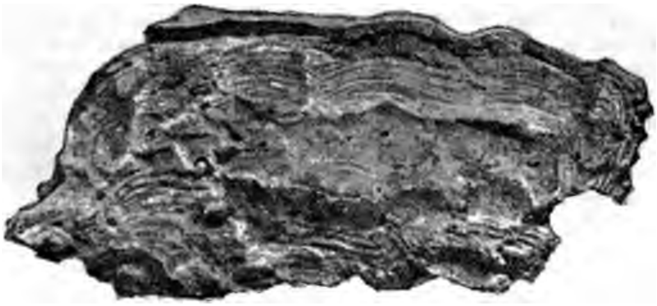

Fig. 3.—Part of a calcareous nodule from No. 4 pit. Nat. size.

The Manganese Nodules.—There are considerable traces of black oxide of manganese both in the clays and limestones of Creechbarrow, but the remarkable nodules which I am about to describe have only been found in the yellow sand underlying the great flint bed on the eastern spur (see p. 152). Here the most beautiful botryoidal masses of this black oxide, which is probably the hydrated peroxide, or psilomelane, are common and of great variety in form. The one figured has a length of five inches, and its specific gravity considerably exceeds that of the manganese nodules which are figured in the description of the voyage of the "Challenger."[1] In other respects there is a general resemblance, the chief difference being that in our case ordinary quartzose sand functions as the material caught up by the mineral instead of fine pumice and volcanic fragments, etc., as in the case of those found at the bottom of the Pacific. I have not seen any nodules from the Pacific where the mamillæ are so salient or so rough as those from the east spur of Creechbarrow, which are handsomer in shape, heavier, and present greater contrast of colours. It is evident that great depth is not absolutely necessary to the formation of manganese nodules, as the Creechbarrow Beds, being associated with fresh-water limestone, could not be other than shallow-water deposits, whilst the manganese nodules from the bottom of the Pacific Ocean were formed in depths between 2,500 and 3,000 fathoms.

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[1] Deep Sea Deposits, pl. ii.

The Creechbarrow Limestone. — Perhaps the first stage in the description of this curious rock should be an illustration of the mode of its growth in the associated sands. This may be well studied in No. 4 pit, where there were several calcareous nodules just underneath the irregular base of the great mass of limestone. The one figured (Fig. 3, p. 153) may be deemed characteristic.

Externally there is a kind of skin made up of very closely set calcitic layers, which have a rough exterior and include a few sand grains. The rest of the nodule consists mainly of carbonate of lime with a small amount of very fine mechanical sediment. In this respect it differs greatly from the manganese nodules, which take up a large quantity of the sandy matrix. The concentric character of this concretionary body is well shown towards the exterior, and occasionally in the interior, but the general mass is a rather light porous material with denser nests of calcitic matter here and there. Some of the holes in the more porous parts are suggestive of slender stems round which deposition in the first instance has taken place, and the aspect generally may be described as tufaceous.

(*To be concluded in the May Number.*)

III.—THE COMPOSITION OF INDIAN LATERITE.

By H. WARTH, D.Sc. Tübingen, and F. J. WARTH, B.Sc. Lond. and Birmingham.

AFTER the appearance of Mr. T. H. Holland's paper on Laterite in the GEOLOGICAL MAGAZINE, February number (pp. 59–69), we can at once give the results of our analysis of Indian laterite, without further introductory remarks. They are as follows:—

I. *Pure Gibbsite from Kodikanal, previously recorded in the Mineralogical Magazine, May,* 1902.

H_2O	33·74
SiO_2	2·78
TiO_2	·04
CaO	·20
MgO	·03
Fe_2O_3	·44
Al_2O_3	62·80
	100·03

Molecules of water for one molecule of alumina = 3·06, which agrees very closely with the formula of gibbsite, $A_2 O_3 + 3 H_2 O$. Specific gravity = 2·42.

II. *Composition of four Bauxites very rich in alumina, and containing little iron, closely resembling the variety called 'Wocheinite.'*

	2 Kh.	3 Pl.	4 Sr.	5 Rw.
$H_2 O$ ...	26·47 ...	24·00 ...	28·10 ...	26·94
$Si O_2$ ...	·93 ...	1·79 ...	2·01 ...	2·35
$Ti O_2$ ...	1·04 ...	3·30 ...	6·49 ...	6·61
$Ca O$ ...	·36 ...	·04 ...	·45 ...	·15
$Mg O$ ...	— ...	·02 ...	— ...	*nil*
$Fe_2 O_3$ ...	4·09 ...	6·21 ...	5·48 ...	6·53
$Al_2 O_3$ ...	67·88 ...	64·64 ...	58·23 ...	57·50
	100·77	100·00	100·76	100·08

Molecules of water for one molecule of alumina:

2·23 ... 2·11 ... 2·75 ... 2·67

If we take the mean of these figures and calculate the proportion of gibbsite and diaspore ($Al_2 O_3 H_2 O$) in the mixture, we find 72 per cent. gibbsite and 28 per cent. diaspore. As the proportions vary from 55 per cent. to 88 per cent. gibbsite, we may roughly say that these rich bauxites or 'wocheinites' consist of about three-fourths gibbsite and one-fourth diaspore. Specific gravities: No. 3 = 2·59; No. 5 = 2·39.

III. *Composition of* 8 *specimens of Laterites in sitû which are Bauxites.*

	6 Marwara.	7 Mahab.	8 Satara.	9 Nilgiris.	10 Nilgiris.	11 Pulsa.	12 Karad.	13 Satara.
$H_2 O$ ...	26·82 ...	24·99 ...	23·88 ...	20·70 ...	19·00 ...	15·87 ...	11·82 ...	14·39
Quartz, $Si O_2$	— ...	— ...	— ...	— ...	10·52 ...	— ...	1·77 ...	—
$Si O_2$ ...	3·90 ...	·72 ...	·37 ...	3·14 ...	·23 ...	3·56 ...	4·20 ...	·90
$Ti O_2$ ...	·38 ...	·42 ...	4·45 ...	— ...	·10 ...	·13 ...	·10 ...	1·59
$Ca O$ ...	·35 ...	·00 ...	·86 ...	— ...	·40 ...	·52 ...	*nil* ...	·64
$Mg O$ ...	— ...	— ...	— ...	— ...	— ...	trace ...	trace ...	·20
$Fe_2 O_3$ ...	13·75 ...	23·41 ...	26·61 ...	37·88 ...	34·37 ...	47·27 ...	51·25 ...	56·01
$Al_3 O_3$ ...	54·80 ...	50·46 ...	43·83 ...	38·28 ...	35·38 ...	32·65 ...	30·86 ...	26·27
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Molecules of water for one molecule of alumina:

2·80 ... 2·83 ... 3·11 ... 3·09 ... 3·07 ... 2·77 ... 2·19 ... 3·13

Average of the above = 2·87, which implies 93·5 per cent. gibbsite to 6·5 per cent. diaspore, with variation from full gibbsite to 60 per cent. gibbsite.

These bauxites in blocks and in powder are generally red with a shade of brown; No. 9 is light brown, Nos. 12 and 13 are of a deep red.

IV. *Composition of ten detrital Laterites.*

	14	15	16	17	18	19	20	21	22	23
Locality	BELGAUM DISTRICT.			JABALPUR.	DHARWAR.	BALAGHAT.	BIRBHUM.	MADRAS NEIGHBOURHOOD.		
Colour when pulverized ...	lavender.	red.	brown. red.	red.	redd. brown.	brown.	redd. brown.	redd. brown.	brown.	ochre.
H_2O	13·31	11·42	11·61	10·93	9·64	7·73	9·60	8·66	8·40	10·74
Free quartz, SiO_2	32·24	6·67	8·93	4·53	16·65	39·53	6·29	28·04	32·46	24·39
Combined SiO_2	9·94	13·35	16·69	23·32	14·79	7·96	17·49	14·07	13·33	10·42
TiO_2	·04	·25	·10	·43	·02	·01	·04	·01	·01	·01
CaO	·00	*nil*	·00	*nil*	·04	—	·03	*nil*	·06	·38
MgO	*nil*	*nil*	*nil*	*nil*	trace	—	*nil*	—	—	trace
Fe_2O_3	8·77	41·50	35·69	28·99	35·81	28·38	42·33	30·51	35·34	47·39
Al_2O_3	35·70	26·81	26·98	31·80	23·05	16·39	24·22	18·60	9·93	6·67
Total ...	100·00	100·00	100·00	100·00	100·00	100·00	100·00	99·89	99·53	100·00

The same, with the clay calculated separately from the combined silica (Kaolin $= Al_2Si_2O_7 + 2H_2O$) :—

		14	15	16	17	18	19	20	21	22	23
Free quartz, SiO_2		32·24	6·67	8·93	4·53	16·65	39·53	6·29	28·07	32·61	24·39
Clay as Kaolin, $Al_2Si_2H_4O_9$		21·42	28·77	35·97	50·26	31·88	17·16	37·69	30·33	(27·39)	(20·22)
Balance identical with Bauxite.	H_2O ...	10·33	7·41	6·60	3·93	5·20	5·34	4·35	4·45	4·42	7·61
	TiO_2 ...	·04	·25	·10	·43	·02	·01	·04	·01	·01	·01
	CaO ...	·00	*nil*	·00	*nil*	·04	—	·03	*nil*	·06	·38
	MgO ...	*nil*	*nil*	*nil*	*nil*	trace	—	*nil*	—	—	trace
	Fe_2O_3 ...	8·77	41·50	35·69	28·99	35·81	28·38	42·33	30·55	35·51	47·39
	Al_2O_3 ...	27·20	15·40	12·71	11·86	10·40	9·58	9·27	6·59	—	—
	Total ...	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The above specimens of Indian laterite are arranged in order of their contents of free alumina, with the exception of the first, the pure gibbsite, which, however, is the richest in alumina if the water is eliminated. The specimens range from 68 per cent. of free alumina down to nothing. There is thus every gradation in alumina from nearly theoretically strongest downwards, with no gap to speak of. If, however, we take into consideration the other constituents we find the specimens to fall into four distinct groups.

I. By itself stands the gibbsite from Kodikanal, which is so much free of foreign matter that in the ignited state it contains nearly 95 per cent. of aluminium oxide. As stated in the notice in the Mineralogical Magazine, this mineral was found to form a deposit of one foot in thickness, consisting of loose crusts or plates which gave the impression of having been extracted from the underlying charnockite. The sp. gr. of this gibbsite was 2·42.

We next come to specimens of the far more extensive and thick-bedded surface deposits, which have hitherto all been classed under the name 'laterite.'

II. Of these laterites the first four specimens belong to our second group. They agree, as already stated, very well with those richest bauxites which have been given the separate name 'wocheinite.' They are characterized by their small amount of iron, and have even less silica than the recorded analysis of the celebrated original wocheinite, on an average 1·77 per cent. compared with 6·29 per cent. at Wochein. On the other hand they contain much more titanium - dioxide. This large proportion of titanium - dioxide (maximum 6·61 per cent.) is very characteristic of the rich bauxites, and a reference to the whole of the tables will show that the titanium-dioxide gradually decreases with the free alumina until there is only ·01 per cent. left. It remains a subject for further enquiry in what form the titanium exists when there is such a large proportion. From the fact of its dissolving when the entire mineral is treated with hot hydrochloric acid, and because there is always enough iron present, we are inclined to believe that it exists chiefly as ilmenite. As already mentioned, the specimens of this group are mixtures of about three-fourths gibbsite and one-fourth diaspore (by weight). The mean specific gravity of two specimens was 2·49, which is more than that of the Kodikanal gibbsite. Our specimens have also the characteristic pisolitic structure, the globules varying from two to four millimetres in diameter.

III. The third group includes specimens such as geologists have hitherto called high-level laterites. They are bauxites which have formed from highly ferruginous igneous rocks. They belong mostly to the area of the Deccan trap, and we find that the proportion of ferric oxide in these bauxites is in close relation to the proportion of iron in the trap. In the same way the small proportion of iron in the preceding group of wocheinites indicates their origin from less ferruginous, probably gneissic rocks. A glance at the table, group III, also shows the regularity with which the water decreases in the same order as the alumina, whilst the iron increases simultaneously.

Only in one case, that of No. 13, is there a slight departure from the rule. With the exception of two specimens containing quartz-sand, the quantity of silica is very small. Sample No. 7 contains only 1·14 per cent. of substances other than the oxides of iron and aluminium besides water. The ferric oxide appears to be entirely or nearly entirely anhydrous. If this were not the case we should obtain a regularly increasing series for the molecules of water calculated from the total of the water for one molecule of alumina. Although the table shows that the figures vary, there is no great departure from the average, and, as already remarked, the mean of all the eight specimens implies anhydrous ferric oxide and a mixture of 93·5 per cent. gibbsite and 6·5 per cent. diaspore.

The identity of these high-level laterites with bauxite is also proved by comparison of their composition with that of other bauxites. Our No. 7 is almost identical with the bauxite from near Giessen with which Dr. Max Bauer compared the specimen from Mahé in the Seychelles.

Our specimen No. 9 comes very close to an Irish bauxite which has been analysed by Siemens, who found the following, according to Watts' Dictionary of Chemistry:—

H_2O	21·5
SiO_2	3·5
TiO_2	2·0
Fe_2O_3	38·0
Al_2O_3	35·0
	100·0

Treated before the blowpipe, all the specimens of group No. III are infusible, the general character of bauxite. Only in the case of No. 10 there were minute fused spots in small number, and No. 12 showed also traces of fusion, though they were doubtful. This behaviour of No. 10 and No. 12 is no doubt due to these specimens containing more silica than the others and free quartz-grains. This infusibility serves to distinguish the pure bauxites when mixed with Fe_2O_3 from the low-level laterites of the following group, No. IV, which (No. 14 excepted) fused unmistakably. Pure kaolins are also infusible, but if the material is distinctly red from iron the test holds good.

IV. The fourth group includes low-level laterites arranged in order of free alumina which calculation shows them to contain. The presence of free silica in the form of quartz is proved in all cases, and confirms a principal character of these deposits. Whenever distinct quartz-grains are seen in quantity, some of them being at times rather large, we may be sure that we have a detrital or low-level laterite. Besides the quartz-sand there is, however, generally an even larger proportion of clay.[1] This follows from the proportion of combined silica which is present, and which we may fairly assume to be a constituent of clay. In the table the amount of clay is calculated according to the composition of pure kaolin (kaolin equals SiO_2 46·4 per cent., Al_2O_3 39·7 per cent., H_2O 13·9 per cent.). The balance which is left after deducting both free quartz and clay consists of free alumina and ferric oxide with water. This is really the substance of bauxite, with gradually decreasing proportion of alumina. The results of the analysis agree thus remarkably well with the theory according to which the low-level laterite is derived from the high-level laterite, and has during its transport to a new site taken up sand and clay as impurities. Further, the results show that the term laterite has a distinct meaning throughout the many varieties of this rock. Laterite is bauxite in various degrees of purity, from the richest wocheinite down to such specimens in which the free alumina has entirely disappeared. In this sense the specimen from Burmah which has been analysed by Captain James, and recorded in the Manual of the Geological Survey of India, is also still a true laterite. Its composition is similar to that of our two last specimens, No. 22 and No. 23. The sample contained 30·7 per cent. quartz and 14·8 per cent. clay, and the balance was made up almost completely of ferric oxide (47·4 per cent.) with 4·7 per cent. water and only 1·3 per cent. free alumina.

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[1] On the average 30 per cent. of clay and 20 per cent. of free quartz.

It cannot be said with certainty what the state of hydration of the alumina is in these detrital laterites. They vary so much in composition, and the colours indicate that the ferric oxide may in some cases be anhydrous and in other cases be present as limonite. Taking all the specimens together, the average composition is such that there is about as much diaspore as there is gibbsite and about as much hematite as there is limonite.

As regards the method of analysis, we found fusion with hydrogen sodium-sulphate the best, if not the only method for all cases. By it the free silica is readily determined as distinct from the combined silica, the iron is obtained in solution, and so is the titanium. With larger proportions of titanium (1 per cent. TiO_2 and upwards) we resorted to the method of separation by long-continued boiling, and small proportions of TiO_2 were determined colorimetrically by means of hydrogen peroxide.

To carry out this work at a distance from India would have been impossible, had we not received very liberal help in procuring specimens from a deposit which extends over an area of thousands of square miles. We desire to express our thanks to H.M. Secretary of State for India, through whose kind intervention the bulk of the very richest and most important specimens came into our hands; also to Mr. Edgar Thurston of Madras and to Dr. D. Hooper of Calcutta, who obtained for us the specimens by which the true nature of the high-level laterite was proved for the first time.

REVIEWS.

I.—Volcanic Studies in Many Lands; being reproductions of photographs, by the Author, of above one hundred actual objects, with explanatory notices. By **Tempest Anderson**, M.D., B.Sc. Lond., F.G.S., F.R.G.S., Fellow of University College, London, Hon. Sec. Yorkshire Phil. Soc. 4to; 202 pages, 105 plates. (London: John Murray, Albemarle Street, 1903.)

PHOTOGRAPHY has become, to a certain extent, the handmaid of Science, and Geology especially is indebted to this delightful art for many a faithful picture. The glacialists have long availed themselves of this method of delineation, whilst the British Association has shown its appreciation of the value of photography in its application to geology by the appointment of a committee to arrange for the collection, preservation, and systematic registration of photographs of geological interest in the United Kingdom. Since 1889, when it was first constituted, this committee has collected several thousand photographs, many of which are of the highest value, and a selection from these is now in course of publication.

It is not surprising, therefore, that Dr. Tempest Anderson, having already acquired considerable skill in the art of photography, and being, moreover, of a scientific turn of mind, should have chosen to illustrate volcanic phenomena with the camera, as a method of spending a physician's holiday at once useful and agreeable. Vulcanology was more especially selected, as it had the advantage of giving opportunities for exercise in the open air and frequently in districts remote and picturesque. For the last eighteen years the author has spent the greater part of his holidays in this fashion. During that period, Vesuvius, Etna, the Lipari Islands, Auvergne, the Eifel, the Canaries, Iceland, British extinct volcanic regions, and many localities on the western side of the North American continent were visited. In delineating those phenomena he has chosen the mechanical side of the subject, "the mode of formation of volcanic cones and lava-streams: how the materials forming them got to their present position, and remained there rather than elsewhere; how they have affected the other rocks with which they came in contact, baking and hardening some, dissolving and removing others; in some cases by their superior hardness protecting the rocks over which they have been deposited, while the surrounding parts have been removed by denudation, so that what was once a molten stream on the floor of a valley is now a bed of hard, perhaps columnar, lava, capping a long hilltop, while in other cases the volcanic beds themselves have suffered most from denudation; how veins and intrusive sills are sometimes harder than the rocks they traverse, and weather out into 'Giant Walls,' but in others are softer, and become gullies and the beds of streams."

The author has long been known as a demonstrator in vulcanology, having commenced his public career before the British Association at Aberdeen in 1885, when he read an illustrated paper on the Volcanoes of the Auvergne. At the Bath Meeting in 1888 he read a similarly illustrated paper on the Volcanoes of the Two Sicilies. He has also been in the habit of exhibiting at the soirées of the Royal Society, and these exhibitions were systematized into four lectures (the Tyndall lectures) delivered at the Royal Institution. It is scarcely to be wondered at that, with such a record, Dr. Anderson was appointed a member of the commission sent out last Summer by the Royal Society to investigate the results of the eruptions in the Windward Islands. Oddly enough, he was on the point of bringing out the present work when this journey was commenced, so that the delay has enabled him to introduce a few of his West Indian photographs.

The first seventeen plates of the work, together with their explanatory text, are devoted to Vesuvius and its vicinity, and in this connection the eruption of 1898 occupies an important place. The character of these lavas is strikingly exemplified, especially where the picture is taken at close quarters, showing a *coulée* of lava of the corded type (a slaggy lava). This stream is small and narrow, whilst some of the loose blocks around approach the cindery or scoriaceous type of lava. For comparison there is a photograph of blast furnace slag from Seaton Carew. Here we perceive the effects of a tip of molten slag down a spoil-bank, thus producing a flow of artificial corded lava marvellously like the natural product. These two types of structure, viz. the corded (slaggy) and the cindery (scoriaceous), are mainly dependent on the amount of aqueous vapour, which, if excessive, renders the cooling stone vesicular, so that a lava-stream may be slaggy in one part and cindery in another.

Next we are presented with the actual phenomena of eruption as noticed in the middle of September, 1898. One of these pictures shows the moving of lava on the steep slope in the act of solidifying as a cascade of stones, in this case of the scoriaceous type. The picture is so graphic that we might almost fancy we heard the rattling. Then we are shown a part of the crater, as it existed during a phase of the same eruption—a vast pit probably a quarter of a mile in diameter, with almost vertical sides, the actual depth being obscured by the vapours issuing therefrom: the quaquaversal inclination of the strata of lava and tuff is well brought out. Showers of red-hot stones were coming out of the bottom of the pit, but the author was fortunate perhaps in not being able to photograph any of these. Finally, we have in pl. x a picture of the explosion, which occurred two days afterwards, as seen from the Observatory, the magnificent cloud of vapour and ashes being intensified by the slanting rays of the sun.

These photographs of the phenomena of eruption more especially appeal to the vulcanologist, but there are others likewise of great geological interest. Ever since the days of Lyell the Phlegræan Fields have been classic ground for all those who seek to interpret the past through the action of the present. There is probably no more exquisite example of a crater, presumed to be extinct, than that of Astroni (pl. xiii), whose picturesque and wooded interior affords such a telling section of consolidated volcanic ash dipping away from the centre of the cavity. As a mere artistic study this picture is specially worthy of commendation. Well-defined extinct craters are by no means rare in the world; there are plenty in the Auvergne. Yet in some cases the interest is enhanced by their enclosing a lake, such as the Pulvermaar in the Eifel or the Lac d'Issarlès in Central France. But the queen of crater lakes is to be found in the Cascade Range of Oregon (pl. lxxxiii). This, again, is a most telling picture, though the outward dip of the beds is not so obvious, owing partly to a considerable accumulation of talus. The dimensions are very great, as the following statement will show:—"An explosive eruption of enormous magnitude has removed several thousand feet of the summit and distributed the material over the surrounding country. The result is a crater about 8 miles by 6 in size, the rim of which reaches a height of about 8,000 feet above the sea. The cliffs rise about 2,000 feet above the surface of the lake, which is in places 2,000 feet deep." An island in this marvellous lake shows a crater within a crater, and had this been still larger it would have been comparable, he observes, to the Peak of Teneriffe, which is surrounded by an old crater-ring of about the same size.

It will scarcely be necessary for us to follow the author through the Lipari Islands and the Canaries, in both of which groups most interesting volcanic phenomena are faithfully delineated by his camera. But the extinct volcanic region of Central France calls for special attention on the part of geologists, and to this region about a dozen plates are devoted. The first of these plates (No. xxviii) is a remarkable piece of topography, being a sort of general view of the chain of the Puys, looking south from near the summit of the Puy de Dôme. Notwithstanding the difficulties of dealing with such an extended landscape, the outlines are clear even to the most distant hills, and the effective side screen of domite in the foreground, besides reminding us of that peculiar rock, gives an artistic touch to the entire composition. The companion picture, looking north, if less artistic, is even more important from a topographical point of view, as we almost look down into the crater of the Puy de Pariou, while the positions of the Grand Sarcoui, the Puy Chopine, and other noteworthy puys are indicated with great distinctness. In the succeeding plates we are introduced to the Puy Chopine and Grand Sarcoui at close quarters. The peculiar elongated dome shape of the latter is well brought out, and it is possible to believe that it was extravasated as a pasty mass in the position it now occupies between two scoria-cones on either side of it.

Having dealt with the phenomena of the acid rocks in Central France, Dr. Anderson presents us with some very striking pictures of the effects of basalt in that region, and he has in many cases selected basalt necks for illustration. In some instances these necks, by resisting denudation, have given rise to most singular isolated pinnacles of rock, often crowned with a building like the Rocher de St. Michel. In this case he considers that the material forming the pinnacle originally accumulated in a volcanic chimney as an agglomerate; the scoria-cone, which once probably surrounded or crowned the whole, has been denuded away, and the more durable rock, forming the neck, alone remains.

The delineation of columnar structure in basalt has received great attention from Dr. Anderson, and his efforts in this connection have been very successful. Central France, the coast of Antrim, and the Eifel are amongst the regions which he has specially selected. Let us take, for instance, the "Valley of Jaujac in the Ardèche" (pl. xxxviii). The subject has attracted the notice of many a geologist, and our readers may remember that the "volcanic cone and basaltic lava-current of Jaujac" constitutes the frontispiece of the second edition (1858) of Scrope's "Volcanoes of Central France." Our author's photograph deals with a limited portion of Scrope's original picture. Pl. xxxviii, in our opinion, serves to illustrate the character of this work on volcanic studies, where a landscape of extreme interest and beauty is also rendered most instructive as a geological section, showing columnar basalt at the bend of the river. There seem to be two beds, totalling 150 feet vertical, but the author regards these as the result of one lava-stream, "the appearance of division being produced by the line of junction of the columns of which both portions are composed, and which owe their origin to cracks due to contraction by cooling of the upper and lower surfaces respectively, and their extension inwards until they meet."

Whilst dealing with the subject of columnar basalt attention may be directed to remarkable examples in the Eifel district (pls. lxxviii, lxxix*a*, and lxxx). The Käsekellar is a noted instance, where the basalt is massive above and sub-columnar below, breaking up into short joints like Dutch cheeses, whence the name. Equally remarkable in a different way is the structure of the Hummelsberg, showing a system of fine vertical columnar jointing, which almost reminds one of fibrous serpentine (chrysotile) on a large scale; whilst the disposition of the basaltic column in the Mindenberg is held to be an example of cooling from the top; the structure is very peculiar. There are also two very effective pictures (small) of the Giant's Causeway, whilst the relations of the basalt to the Chalk on the coast of Antrim are fully depicted and their historical significance dealt with in the text.

There remains one very extensive subject, viz. Iceland, to which thirty plates are devoted. To do anything like justice to this part of the work would almost require a separate notice. Dr. Thoroddsen has animadverted lately in very severe terms on the majority of modern works on Iceland, as consisting largely of personal details. Nothing of the sort can be alleged against Dr. Anderson. He appears to have spent two Summers there, and his photographs tell their own story of this treeless land of frost and fire, with occasional assistance by way of interpretation in the text. It is a triumph of the positive method as against the flood of speculation with which geological literature is occasionally inundated.

The Hafragil's Foss in the valley of the Jökulsá (pl. xlix) is a fine specimen of terrace cutting through horizontal volcanics of an older series. This river may be regarded as typical of Iceland, since it rises beneath the ice-sheet of the Vatna Jokul, and after running through the terrible waste of the Myvatn's Öroefi, finally discharges as a regular glacier river into the Asar Fjord on the north. In pl. L, a more specialized section is given, where the same river is seen plunging into a cañon about 400 feet deep, cut in the columnar basalt. The author again points out that the separate layers observed here need not in all cases represent a different eruption, and he refers to his remarks on the Jaujac section (pl. xxxviii) as applicable in this case. At the northern end of the Jökulsá gorge some remarkable volcanic structures are exhibited as the result of the injection of basaltic lava into volcanic ash (pls. lii and liii).

One other subject in connection with the copious illustration of Icelandic phenomena must suffice—we refer to the fissures termed Gjás, due to the unequal settlement of the lava-crusts on cooling. These seem well developed in the Reykjanes peninsula, and are partly due to the formation of tunnels, whereby the still liquid lava continues to flow after the surface has consolidated. The mouth of one of these old tunnels is shown as a lava-cava at Myvatn (pl. lxxii). The celebrated Almannagjá in the valley of the Oxerá is an instance of a Gjá (pl. lviii), and this has all the appearance of a road hollowed out between a cliff and its undercliff. But the most interesting series of Gjás, from an historic point of view, are those which surround the Logberg, on which the Icelandic Parliament met at Thingvalla. The half-plate, No. lxi, shows us this curious rock table, held up in a fork between two faults and almost surrounded by deep Gjás, full of water, fresh, clean, and running — a nice place to cool the ardour of an obstreperous legislator!

There are many interesting photographs from well-known volcanic regions on the west side of the North American continent; and the author, as we have already noted, has just had time to add five very graphic pictures of the recent West Indian eruptions. We trust, however, that we have already indicated sufficient to give a general idea of the work, which has been a labour of love, occupying the author's spare time for the last eighteen years. In this work art and science are happily combined, so that our æsthetic tastes are gratified, whilst we are receiving instruction in the mechanism of volcanic action, past and present. May we not say that the author and photographer has realized the *Omne tulit punctum qui miscuit utile dulci* of the Latin poet?

Whilst expressing our admiration of this work we must draw attention to a passage on page x of the preface, where the author states "that the mere enumeration of books and papers on Vesuvius and the other South Italian volcanoes occupies 340 *quarto pages* of a Report of the Geologists' Association." Apart from the inherent improbability of a mere list of the literature of the subject occupying 340 quarto pages, we are in a position to state that the present librarian of the Geologists' Association knows nothing of any such report.

W. H. H.

II.—MINERALOGY: AN INTRODUCTION TO THE SCIENTIFIC STUDY OF MINERALS. By HENRY A. MIERS, D.Sc., M.A., F.R.S., Professor of Mineralogy in the University of Oxford. pp. xviii and 584, with two coloured plates and 716 illustrations in the text. (London: Macmillan & Co., 1902. Price 25*s*. net.)

HITHERTO, when asked to recommend a textbook on mineralogy, one has been at a loss to name a book suited to the needs of the student or serious general reader. With the appearance of Professor Miers' long-promised work, this difficulty vanishes, and the book may be unhesitatingly recommended as a really *readable* work, setting forth the principles of scientific mineralogy, and not unduly burdened with facts and technical details. Most of the textbooks hitherto attempted are little more than catalogues of the characters (often imperfectly determined) of mineral species, and of the localities, more or less uninteresting, where they are found. Much of this tedious detail, only in place in larger works of reference, has been omitted in the present book; Professor Miers has clothed the dry bones of mineralogy and produced a work full of life and interest. Had such an introduction to the study of mineralogy appeared years ago, there can be little doubt but that the science would be a more popular study than it now is in this country.

One of the most striking features of the book is its wealth of illustration. The numerous figures, all original be it noted, are in every way excellent; indeed, it would be possible to gain a very good idea of the subject by simply studying the figures and the lucid explanations with which they are accompanied. The representation of minerals as they actually occur in nature, in addition to idealized outline drawings of crystals, has been attempted in but few works on mineralogy, and, as far as we know, in no English textbook hitherto published. Many of these in the present work have been reproduced directly from actual specimens by photographic processes. Photographic reproduction, however, frequently fails to bring out the relation between the planes and edges of the crystals represented; this difficulty has been overcome in the present work by reproducing artistic black and white drawings of actual specimens, the characteristic features of which are brought into special prominence. The lines representing the edges of the crystals in many of these figures might with advantage be a little less heavy, but otherwise they are altogether excellent. In addition to the figures in the text are two coloured plates, the one representing an interference figure as seen in monochromatic light and the other the same figure seen in white light. Reproduced directly by photography and three-colour printing, these figures are probably the first of their kind to appear in textbook illustration.

The subject-matter of the book is divided into two parts of about the same length, each of which presents several novelties of treatment. Part I deals with the essential properties of minerals, and Part II consists of a description of the more important mineral species. The first chapter of the book, treating of geometrical crystallography, will give the beginner a clear idea of the symmetry and form of crystals; it does not pretend to be exhaustive, and the mathematical relations, though clearly and briefly set forth, are not brought into prominence, nor are any detailed examples given in the methods of calculating crystals. About half (38 pages) of this chapter is occupied by a description of the different crystal-systems; 22 of the 32 classes are described, all those, that is to say, which are unquestionably represented among minerals. A complete list is given in an appendix at the end of Part I. The names employed in Dana's textbook for the crystal-classes (e.g., calcite class, cuprite class, etc.) have been wisely adopted in place of the unnecessarily long and confusing names (different in every author) which one finds elsewhere.

In the appendix on the crystal-classes, names of the latter type are employed, and like other authors, the present one has not refrained from inventing new terms to denote the different types of symmetry, some of which (e.g., alternating, equatorial, central) seem desirable innovations. This lack of uniformity in nomenclature is doubtless unavoidable in a science which has not been standing still, but it is none the less much to be deprecated. In this connection we may remark that, according to the preface, Dana's mineral names have been adopted; in the text, however, are to be found fluor, pyrites, blende, anatase, copper-glance, mispickel and other names not used by Dana.

In the portion on geometrical crystallography there are short, but useful, chapters on vicinal faces and light figures, and on etched figures, the relation of which to the symmetry of the crystal is specially pointed out. In the appendix above mentioned the symmetry of the 32 classes is indicated by diagrams giving the general forms of etched figures. A brief and clear account of space-lattices is given in an appendix dealing with theories of crystal-structure.

The optical properties of crystals are treated in almost as much detail as the geometrical relations, and should be of value to the student. As remarked in the preface, however, the introduction of both Fresnel's ellipsoid and the indicatrix may be at first somewhat confusing. Of the remaining chapters in Part I, that dealing with the relations between the properties of minerals may be specially mentioned; the remarks on solid solutions, for example, are such as are to be found in no other general textbook of mineralogy.

In Part II, devoted to descriptive mineralogy, no attempt has been made to give a complete list of all the perfectly or imperfectly known mineral species. The author's aim has been rather to give a readable and detailed description of certain minerals selected as types, and to compare other less important species with these types. Rare minerals are sometimes mentioned with the object of elucidating the inter-relations of groups, but no doubtful minerals receive mention. At the head of the description of each type-species is printed in smaller type an enumeration of the principal characters of the species, an arrangement useful for purposes of reference. In place of the usual list of localities is given a description of the mode of occurrence, associations, etc., of specimens from one or two typical localities. Much of the tabular matter, only necessary for purposes of reference, is collected together in appendices. The tables of minerals arranged according to their refractive index, optic axial angle, specific gravity, etc., will be of great use even to working mineralogists.

Finally, the printing and arrangement of the whole book leave nothing to be desired, while a very complete and systematic table of contents and an equally complete and well-arranged index add much to the value of the work. The only drawback to the book is its high price, which we are afraid will make a wide circulation impossible. If the costliness of the work is due to the inclusion of the coloured plates, we are of opinion that these had been better omitted, since they represent only one type of interference figure and form but an incomplete series.

III.—The Borneo Expedition.

Geological Explorations in Central Borneo, 1893–94. By Dr. G. A. F. Molengraaff. With 89 Illustrations in the text, 56 Plates, 3 Maps, and an Atlas (folio) of 22 Geological Maps. English Revised Edition, with an Appendix on Fossil Radiolaria of Central Borneo by Dr. G. J. Hinde. London: Kegan Paul & Co., Ltd., 1902. Quarto: pp. xx, 530; Appendix, pp. 56, pls. iv. Published by the Society for the Promotion of the Scientific Exploration of the Dutch Colonies. Leyden, E. J. Brill; Amsterdam, H. Gerlings. Issued February, 1903. Price £2 12*s*. 6*d*. net.

IT is with no common interest that we have studied the fine volume of text and illustrations, and the large folio atlas of maps which accompanies it, prepared by Dr. Molengraaff and printed in so admirable a manner by our Dutch neighbours (in both an English and a Dutch edition), an undertaking which, although warmly supported by the Dutch Colonial Government, really results from the enterprising spirit of "the Society for the Promotion of the Scientific Exploration of the Dutch Colonies," and sets before our own "Royal Colonial Institute" a splendid example which they would do well to follow.

A considerable delay has arisen in the production of this great work owing to the fact that, soon after Dr. Molengraaff's return to Europe from Borneo, in January, 1895, he was appointed State Geologist to the Transvaal; the preface to the first Dutch edition being dated from *Pretoria*, October 1st, 1899; that of the English edition from Hilversum, March 25th, 1902; but this edition, however, was not really issued until February, 1903.

A glance at the map of Borneo conveys to the mind the idea of vastness. It is one of the largest islands on the globe, being next after New Guinea in extent, and only outrivalled in area by two others, viz. Australia and Greenland, which usually rank as continents. It lies across the equator (7° N. and 4° S.), forming one of the greatest of the East Indian Archipelago, and having an area of 280,000 square miles. Visited first by the Venetian traveller Ludovico Varthema, about 1505, it was next reached by Spain in 1521; the Portuguese followed and established a few ports in 1526, and carried on trade with the natives for over 150 years. The Dutch reached Borneo at the close of the sixteenth century, and remained there for 70 years. The English followed and settled at Bandjermassin in the south till the beginning of the eighteenth century, when they abandoned it owing to the hostility of the natives. The Dutch then returned, and have since 1733 slowly increased their territory, and now hold more than two-thirds of the whole island; but the district of Sarawak, on the west coast, under Raja H.H. Sir C. J. Brooke, the northern part called British North Borneo, controlled by a Chartered Company, and the native Sultanate of Brunei, all these three (covering an area of about 84,000 square miles) are under British protection.

Borneo is a country of high mountains, heavy rainfall, tropical forests, and big rivers everywhere; and, although known to Europeans for nearly 400 years, its interior is still a virgin field for the naturalist and the explorer.

Ethnologically it is a wonderful country, with a mixed population composed mostly of Dyaks, with a large number of Malays and Chinese. Here, on the coasts and in the estuaries and rivers, or on the land for that matter, we have the native race, the Dyaks, living in large communal pile-dwellings; in Brunei, for instance, a population of nearly 7,000 may be found to-day living in dwellings built *entirely on the water*, communication being only possible by boat. In South and East Dutch Borneo the chief town is Bandjermassin on the Riam-kina River; here, again, most of the inhabitants are found living either in *floating raft-houses* (rising and falling with the level of the water) or in pile-dwellings. Those on the land are also built on piles, and are often stockaded around after the manner of the neolithic palisaded and stockaded *terramare* discovered in the Po valley between Parma and Modena; while those on the water are likewise present-day survivals of the precisely similar Swiss and Italian pile-dwellings of prehistoric times. Thus the axiom still holds good, "that man under analogous circumstances acts in an analogous manner irrespective of time and space" (F. Troyon).

The region of Dr. Molengraaff's geological explorations is situated principally in the north-eastern portion of the political division of Dutch West Borneo, and forms part of Central Borneo. It is traversed from east to west by the great river Kapoewas, which takes its rise in the hilly districts of the extreme north-easterly margin of the division, and in its course to the sea receives the waters of numerous large and important tributaries, which flow to it from the mountainous regions bordering both the north and south sides of its basin. The total length of this river, from its source to the sea, is stated to be 1,143 kilometres (710 miles), about 24 kilometres longer than the Rhine. On the north side of the Kapoewas basin is the mountain range known as the Upper Kapoewas, which separates it from Sarawak, and towards the south are the Muller mountains, the elevated Madi plateau, and the Schwaner range, which forms the division between it and South Borneo.

The river Kapoewas forms the main highway of communication, and from villages and stations on its banks the author obtained native boats and helpers, with which he made the ascent of the various tributaries as far as practicable, and when the streams no longer served, the land-route to the mountain ranges and peaks had to be resorted to. But in a country of tropical forest growth such as Borneo it is next to impossible to perform any long journeys on foot; the native Dyak footpaths through the forest—the only land communication—are merely narrow tracks, just wide enough for a single man; they follow a nearly straight course, breasting steep hills and scaling the sides of mountains without a zigzag; they are not diverted by morasses or streams, deep gorges are simply bridged over by trunks of trees, and the only obstacles they bend round are lofty forest trees. As a consequence, land travel is very fatiguing to Europeans. Nor is the journey by boat up the streams in Borneo without its dangers and difficulties, mainly caused by the frequent waterfalls and rapids, where ledges of hard rock cross the river bed and necessitate unloading and a portage; the streams, moreover, are liable to sudden and dangerous spates.

Dr. Molengraaff found that the lines of dislocation of the rocks in the Upper Kapoewas territory followed a generally east and west trend, and this led him to infer that by taking a route from north to south a continuous geological section from the boundary of Sarawak on the north, right across Dutch Borneo to the Java Sea, might be observed. This course was adopted on his return journey, and, starting from Boenoet on the Kapoewas, he travelled southward, crossed the Madi plateau, and, reaching the Schwaner range, made the ascent of Mount Raja, one of the highest peaks (2,278 metres). At Mount Boenjau the water-parting between West and South Borneo was crossed, and descending the Menjoekoei river to its junction with the Samba river, and thence by the great river Katingan, he reached Pegattan, close to the coast, on the 28th October, 1894, and four days afterwards arrived at Bandjermassin by sea. The journey down-stream of 300 miles (not counting river curves) was accomplished in a fortnight. The territory traversed by this southern route was absolutely unexplored scientifically, and the greater part of it had not previously been reached by any European, so that the physical and geological descriptions of it given by Dr. Molengraaff in chapters x, and xi, are of the greatest interest.

The principal end of the expedition, to ascertain the nature and the relative succession of the rocks of Central Borneo, which may be said to be the core of the island, has been successfully carried out by the author, and from his observations we obtain for the first time a satisfactory outline sketch of its geological features. The oldest rocks recognized are strongly folded, amphibolite and chlorite schists and quartzitic slates occurring in the hilly country near

Sĕmitau and other localities. Petrographically they are similar to crystalline schists of Archæan age, but it is possible that they are only sediments altered by granite intrusions.

Next, above the doubtful schists, there is a great thickness of phyllitic clay-slate with a silky lustre, alternating with beds of sandstone, greywacke, and quartzite. The strata are nearly vertical. No fossils have been found, and its age is therefore unknown, though very possibly it is Palæozoic. It has been named the "Old Slate Formation." The Upper Kapoewas range, a typical mountain chain much worn down by erosion, which runs nearly east and west and forms the boundary between West Borneo and Sarawak, and between West and East Borneo for a distance of 225 kilometres, is mainly built up of these slaty strata. On the south side of the range the beds are abruptly cut off by a great fault.

The next younger formation, known as the "Danau Formation," is composed of highly tilted and contorted beds of chert, jasper, and hornstone, quartzite, clay-slate, sandstone, diabase, diabase-tuff, and porphyrite, which have been brought down to the level of the "Old Slate Formation" by a fault. The beds have an east and west strike, and they have been traced from the Lake district for a distance of 280 kilometres, quite into East Borneo. The chert, jasper, and hornstone beds are of organic origin, and are mainly composed of Radiolaria. In the Upper Kapoewas region their thickness is estimated at 100 metres, and they are regarded by the author as deep-sea deposits. The beds of diabase and diabase-tuff, which alternate with the chert and hornstone, are attributed to submarine and volcanic eruptions. Some of the tuff beds likewise contain Radiolaria. This formation is of pre-Cretaceous age, and the Radiolarian beds are probably Jurassic.

A system of moderately tilted and folded beds of marly and sandy deposits succeeds the Danau formation. Along the river Seberoewang the marls contain *Orbitolina concava*, which indicates that they are of Cenomanian (Upper Greensand) age. The deposits were probably laid down near a coast, and a portion of Central Borneo must then have been dry land. The rocks occur in various localities, and extend to the south of the Madi plateau.

The oldest Tertiary deposits in Central Borneo have not been met with *in sitú*; they are only known from boulders of grit, containing *Nummulites* and *Orbitoides*, which occur in the valleys of the rivers Embaloeh and Tekelan; they may be regarded as of Oligocene age.

An enormous area is covered by a formation named the Old Tertiary or Mĕlawi Group, which consists of horizontal beds of sandstone, quartzitic sandstone, and claystone, with intercalated seams of coal. Molluscan shells occur in these beds in places; according to Krause and Martin they are brackish-water forms, which probably lived in estuaries. At the time of their deposition the whole of Central Borneo, with the exception of the Upper Kapoewas range, was submerged beneath the sea. The greater part of the Madi plateau and the Schwaner range, which separates West from South Borneo, are formed of these rocks.

The coal-seams in these Tertiary beds appear to be formed of plant débris and trees brought down by the river floods, and not of slowly formed vegetable growths *in situ*, as is the case with most Palæozoic coal-seams. As a rule, the Borneo coal is too much mixed up with sand and clay to be of economic value, but the author records several localities where the beds are of sufficient purity and thickness to be worth prospecting for mining purposes. They are shown on the north shore of the Kenepai river (p. 38); on the Mondai river (p. 60; also Atlas, Map 6, sect. F & H); below Karangan Pandjang (p. 273); on the Sĕkilit, a tributary of the Tĕbaoeng, several layers of fairly good but somewhat fissile coal were exposed (profile B, Map ix*a*, pp. 288 and 293); and again on the Pinoh river, where a bed of coal of inferior quality rests on claystone beds with concretions and numerous shells (see section p. 142, fig. 35).

Succeeding the Old Tertiary Sandstone formation, there are extensive deposits of fluviatile and lacustrine origin, consisting of beds of fine sand and mud mingled with vegetable débris, which are regarded as probably of Quaternary age; but in Borneo there is such a close resemblance in the sandstones and clays of different ages that in the absence of fossils it is almost impossible to determine between those of Tertiary, Quaternary, and recent dates.

Owing to the heavy tropical rainfall, the denudation of the higher land-areas in Borneo is on an enormous scale, and the gravels, sands, and finer materials brought down by the rivers are spread over extensive areas. Thus in West Borneo, which has a total area of 145,000 square kilometres, it is estimated that 30,000, or nearly one-fifth, are covered deeply with alluvial deposits.

Between the hills and the flat alluvial grounds of most of the large rivers, there are older fluviatile deposits of a gravelly character, which generally contain gold. The gold is obtained by Chinese, who work the beds in a very primitive manner. They are very reticent respecting the results of their operations, which are probably not over remunerative, but if hydraulic machinery were employed the chances of success would be greater.

All the later changes in Borneo appear to be due to atmospheric influences, which have greatly diminished the height of the island, and at the same time enlarged its circumference by the rapid deposition of the alluvial material brought down by the rivers. The finer materials are carried far out to sea, and, from the discoloration of the water round the coasts, Borneo has received its name of "Mudland."

Intrusive and eruptive rocks are largely developed in Central and South Borneo. Granite areas occur in the Schwaner mountains, the base of which principally consists of this rock, and in the bordering hilly districts of South Borneo; also in the Sĕmitau Hills, the Boengan Hills, and the lake district. It is mainly an amphibole-biotite-granite with plagioclase, which frequently passes into tonalite. Its intrusive character is proved by the intense alteration of the surrounding rocks near the zone of contact.

Diorite, gabbro, norite, peridotite, serpentine, and diabase have been met with in different districts.

There are three principal volcanic areas in Central Borneo, the Muller mountains, the northern slope of the Schwaner mountains, and on the Samba river. The most important is the Muller range, forming the south boundary of the Upper Kapoewas plain; its known extent in an east and west direction is 280 kilometres, and its average breadth about 45 kilometres. The whole of the range consists of volcanic rocks; those of the western portion are of a decidedly andesitic character, and those of the eastern of rhyolitic and dacite types. Thick beds of tuff are also present in which there are large quantities of silicified wood, partly stems of trees still in an upright position. The average height of the mountain peaks, which are mere fragments of a former unbroken tuff-plateau, is about 1,100 metres. The volcanic action which produced these mountains is believed to have commenced during or shortly after the Cretaceous age, and, after continuing through the Tertiary, terminated probably about the commencement of the Quaternary period.

In an appendix, Dr. G. J. Hinde gives a description of the Radiolaria which form a large part of the chert, hornstone, and jasper series of rocks, and are present also in the alternating beds of diabase-tuffs, marls, etc., belonging to the Danau formation, mentioned above. The unexpected discovery of these siliceous organic rocks in Central Borneo by Dr. Molengraaff is of considerable interest in view of the fact that within the last few years rocks of a similar character have been found in other parts of the East Indian Archipelago, at Celebes and Billiton, and also in various parts of Europe, in California, Australia, and Japan.

About one hundred different forms of Radiolaria were recognized and described in thin sections of these Central Borneo rocks, and figures of them, carefully drawn by Mr. A. T. Hollick, are given on the accompanying Plates. Of these forms, seventeen occur in the rocks of other countries, and eighty-three are at present only known to Borneo. They show many points of resemblance to the Radiolaria present in rocks of Jurassic age in Switzerland and Italy, and to those of approximately the same age in the coast ranges of California, and it is highly probable that the deposits in Central Borneo in which they occur are likewise of Jurassic age.

In concluding our notice of this most interesting and valuable work, we wish particularly to call attention to the series of maps, charts, and sections in the atlas, and to the striking photographs, illustrating the natural scenery and geological structure of the country, and giving lively reproductions of the people, their homes, both for the living and the dead, and the strangely carved figures and memorial poles which surround their settlements. In the charts of the rivers the salient geographical and geological features of every portion of their course are carefully noted, and the geologically coloured maps and sections enable the reader readily to follow the observations recorded in the text.

The author acknowledges his obligations to Messrs. Schlumberger and R. Bullen Newton for determining the Nummulites; to Dr. Krause and Professor Martin for examining the shells; and to Dr. Schroeder van der Kolk for assisting in the microscopic study of the rocks.

In the preface to the English edition Dr. Molengraaff specially thanks Dr. G. J. Hinde for reading the proofs and revises, and to this supervision may perhaps be attributed the general absence of errors in the text, which are usually too prominent in translations printed abroad. A separate vocabulary of Dyak names of places and things (most of which are given in notes or in the text and index, but *not collectively*) would have proved of service to English readers.

We commend the work to all who are interested in the geology of the East Indies, and hope it will find a place in all the public reference libraries in Britain and America and the Colonies.

IV.—A NEW ROCK-CLASSIFICATION.

QUANTITATIVE CLASSIFICATION OF IGNEOUS ROCKS, BASED ON CHEMICAL AND MINERALOGICAL CHARACTERS, WITH A SYSTEMATIC NOMENCLATURE. By WHITMAN CROSS, JOSEPH P. IDDINGS, LOUIS V. PIRSSON, HENRY S. WASHINGTON. 8vo; pp. 286. (Chicago, 1903.)

THE classification of the igneous rocks is a question which has engaged the attention of many petrologists; and, as a wide divergence of opinion sufficiently attests, it involves problems of much difficulty. The memoir before us is the joint production of four well-known American authorities, and represents, we are told, an exhaustive discussion of the subject extending over many years. Moreover, it is not merely a contribution to a vexed question, but aims at affecting a final settlement of it. For these reasons the scheme put forward, and the arguments upon which it is based, demand a frank and careful consideration.

Our authors start from the proposition, which will scarcely be disputed, that existing methods of classification are illogical and in many respects unsatisfactory. But we are by no means convinced that they have correctly diagnosed the imperfections of the schemes in present use; and on such diagnosis the success of any proposed remedy must necessarily depend. The confusion which prevails in the classification of igneous rocks is in some measure due to causes inherent in the nature of the subject-matter, and especially to the absence of any well-defined 'species,' such as constitute the units of classification in the sister sciences. But the present difficulty is, as it appears to us, attributable in a much greater degree to the rapid and unequal growth of the science of petrology. Fifty years ago the classification of igneous rocks was of the crudest kind, but it seems to have been quite adequate to the state of knowledge at that time. The great revival of petrographical research which followed the introduction of microscopical methods has instigated a large body of workers, and the annual output, especially from the German laboratories, has attained a very considerable volume. The great bulk of this work is of a purely descriptive kind—petrography in the strict sense. Much of it is doubtless of great value; but its value can be only very partially realised, for the reason that this accumulation of material has far outstripped the other side of the science, the business of which is to co-ordinate the scattered observations and bring to light the principles which underlie them. The pearls are there, but there is no thread on which we can string them. During recent years, however, we have witnessed many indications of a reaction from this state of things. From various quarters memoirs have been put forth in which very broad views are taken of the groups of rocks dealt with, the question of their mode of origin being kept constantly in sight. We may remark in passing that American petrologists, including some whose names appear at the head of this article, have taken their part in the advance on these lines. Much stress is now made on the essential mutual relationships of associated rock-types, and Brögger has gone so far as to give a provisional genealogical tree for those of the area which he has made his own. Such essays in the direction of a comprehensive genetic treatment are necessarily tentative, but we have no sympathy with those who would dismiss them as mere speculation. Their influence is already very apparent. Petrologists feel that they have almost within grasp a fundamental principle analogous to that of descent, which lies at the root of classification in the organic world; and this warrants a confident hope that there may emerge in due time a truly natural classification of igneous rocks. If the expectant attitude of mind here suggested is, as we think, very general, the appearance of an elaborate artificial scheme at the present juncture will seem to many a step in the wrong direction.

The standpoint of the authors is clearly defined in one of their prefatory remarks: "The present systems are to a certain extent founded on theory or hypothesis, while classification in order to be stable must eschew all such bases, and be founded only on ascertained facts."

As interpreted by what follows, the stability here made a desideratum must be understood as rigidity; for the argument leads to the setting up of an unyielding framework, in which, between the arbitrary partitions, each rock, whether discovered or undiscovered, may find its appropriate pigeonhole. Although we are under the disadvantage of having no alternative scheme to offer, we venture to submit that an elastic classification, embodying what is known and capable of being adapted to the requirements of increased knowledge, might with equal propriety be described as founded on ascertained facts. At least, it may be pleaded with some reason that existing systems fail, not because they involve a certain element of hypothesis, but in some measure because their implied hypotheses are fallacious.

Some criticism on general grounds we have thought admissible; but the scheme before us is professedly empirical, and we cannot do justice to it without adopting for the purpose the same point of view. The first impression of complexity, due partly to the strange

›logy introduced, is not a just one. The principles upon the whole assemblage of igneous rocks is divided and sub- l are, at least on the face of things, perfectly simple, and they ried out logically and consistently throughout. The criteria ›d to are, moreover, of a strictly quantitative kind, so that all ıity and compromise are excluded, manifestly an advantage if ect is to provide each rock with a precise systematic position me. It follows, of course, since the hard dividing lines have nterpart in nature, that rocks having the closest affinities ›metimes be divorced; but this is a drawback incident to any ry scheme.

basis of classification is mineralogical composition, though ugh statement needs, as we shall see, important qualification. ineralogical criteria selected are such as correspond with more important differences among the rocks themselves, and those are deemed of most importance are used in making the major· ns of the scheme, the principle being carried out, as it seems with skill and judgment. Thus the rock-forming minerals st grouped under two heads, the siliceous and aluminous on ıe hand and the ferro-magnesian on the other, or, as we onveniently say, the light and the dark. The whole of the s rocks are then divided into five great classes, according ratio which the total light minerals bear to the total dark:—

Light minerals extremely abundant; ratio greater than 7 : 1.
Light minerals dominant; ratio between 7 : 1 and 5 : 3.
Light and dark minerals nearly equal; ratio between 5 : 3 and 3 : 5.
Dark minerals dominant; ratio between 3 : 5 and 1 : 7.
Dark minerals extremely abundant; ratio less than 1 : 7.

ı we may regard as in some sense an extension of Brögger's ratic and melanocratic groups. In the first three classes isions are made with reference to the nature of the white ıls, five subclasses being defined in each class according to the of quartz, felspars, and felspathoids on the one hand to lum and zircon on the other. In the last two classes, dark minerals preponderate, these are made the basis of a like ision, the critical ratio adopted being that of pyroxenes, ›, and magnetite to apatite, etc. This produces an ill-balanced ;ement, for it is evident that in every class the first subclass greatly outweigh all the others. It is, however, easier to se the scheme in these particulars than to improve it. It is ossible here to follow out all the details of this ingenious ;ement, and we will only note how the subclasses are divided ·ders. In the first three classes this is effected with reference preponderance of quartz, felspars, or felspathoids among the minerals. Since quartz and the felspathoids are 'antithetical,' ing found in company in igneous rocks, it is possible here to once the ratios of quartz to felspars and felspars to felspathoids; leads to nine orders in each subclass, the dividing ratios being the same as before. In classes iv and v each subclass is divided into five orders, according to the ratio of pyroxenes and olivine to iron-ores. By further particularisation of the constituent minerals the authors establish successively suborders, rangs, subrangs, grads, and subgrads. The reason given for the spellings 'rang' and 'grad' is that 'rank' and 'grade' are so frequently employed in a general sense, but this consideration will not console French and German readers. For our part, we are loth to see the words 'class' and 'order' tied up to special meanings, and should have preferred to borrow such terms as 'domain' and 'nome' from the vocabulary of the older systematists.

This leads us to notice that the new classification is expressed throughout in terms of a new nomenclature. Given the one, we must indeed grant the necessity for the other. As the authors justly remark, petrology has suffered sufficiently from the redefining of terms, a license which would not be patiently conceded in any other branch of science. It is, moreover, a part of their design that each term shall carry its own precise meaning on its face. To this end they have boldly thrown aside the Greek lexicon, and constructed new words, each of which is a frank barbarism, but conveys an explicit meaning on a certain mnemonical plan. Thus the two groups of minerals, which we have distinguished above as the light and the dark, are designated by what the late Lewis Carroll called 'portmanteau-words'; *salic*, recalling *s*-ilica and *al*-umina, and *femic*, suggesting ferro-magnesian. The five classes of rocks are named persalic, dosalic, salfemic, dofemic, and perfemic. A like method is pursued through all the minor divisions. In spite of its obvious utility, it has at first a decidedly irritating effect, and will not improbably prejudice the reception of the scheme. These uncouth classificatory terms, however, need not be often used in speaking of the rocks themselves, for each subdivision inferior to subclass is provided with a proper name derived from some country or locality where the rocks are typically exhibited. We have thus, for a granodiorite from the Yosemite, the order Britannare, rang Toscanase, subrang Toscanose. Different terminations are used to mark divisions of different magnitude or status, a feature which, we think, must be commended. The termination *-ite* is at present greatly overworked, and a novice might plausibly suppose lherzolite to be something of equal importance with granite.

The only serious criticism that we have to make upon the new classification, regarded as a purely empirical scheme, remains to be noticed. The percentage mineralogical composition which is the basis of classification is an *ideal* one, which may or may not agree with the actual composition, and in some cases departs widely from it. Thus the leucitite of Capo di Bove is assumed, for the purpose of fixing its systematic position, to contain about 11 per cent. of anorthite and 9 per cent. each of olivine and akermanite, although none of these minerals is actually present in the rock. Some of the actual constituents, melilite and biotite, are discarded, because their complex formulæ make them unsuitable to be included in the list of 'standard' minerals recognized in the scheme. The authors would justify this treatment, "not only by the fact of the variable possibilities of crystallization in one magma, but because of the difficulty of determining the quantity and chemical character of the minerals actually present in many rocks. It is further warranted because of the impossibility of determining the minerals in a great number of rocks in which they are too small, and because of the incomplete crystallization of all more or less glassy rocks."

It seems to us that artificiality is here pushed to the extreme limit, and an element of complexity, very burdensome in practice, is dragged in. Rules of an elaborate kind, though presumably sufficiently definite, are given for calculating the ideal mineral composition or 'norm' from the chemical analysis of the rock. Further, we are told that a knowledge of the actual mineral constituents and their true percentages, even when they are all 'standard' minerals, is not sufficient; we must calculate from this to the chemical composition, and thence back to the norm. The norm is thus merely a circuitous device for presenting the chemical composition, and we are tempted to ask why the latter was not taken directly as the basis of classification. A scheme beginning with five classes defined by silica-percentage, and proceeding to minor divisions with respect to the other chemical constituents, would seem to offer the advantages without the drawbacks of the scheme before us. It must at least be recognized that the quantitative precision which is the characteristic of this system recoils upon its inventors, since a like minute accuracy is requisite in the diagnosis of every rock-specimen. We question whether a given rock could ever be referred with complete confidence to its place in this scheme in the absence of a trustworthy bulk-analysis, and even this might fail unless a perfectly fresh specimen were forthcoming.

It is impossible in the space at our disposal to present a complete account of the scheme with all its ingeniously contrived details. If we have in any respect misapprehended its scope, we must plead the complete novelty of the system and its elaborate aspect upon a first view. Assuredly we have not approached it in any unfriendly spirit, saving only the predilection we have avowed for a more natural treatment, or, in other words, our desire to see the Gordian knot untied and not cut. There remains the consideration that the success of what purports to be a practical scheme depends ultimately upon its innate power of commending itself to practical workers. We learn that the new classification has already gained adherents in America, but we doubt whether it will find favour, e.g., in the German Universities, from which so large a proportion of our petrographical work emanates. It suggests, partly perhaps by its quaint nomenclature, a comparison with Volapük and Esperanto. Now there is something in human nature which ordains that languages shall grow, and not be produced ready-made; and, whether we call this stubborn conservatism or an instinctive grasp of the evolution philosophy, it insinuates a foreboding for the scheme before us, no less than for its terminology.

Our criticism, so far of a merely destructive kind, will be made more intelligible if we may be allowed to indicate roughly the lines on which, as we think, a real advance may be looked for. Instead of beginning at the top and dividing down, we would begin at the bottom and build up. The unit of classification would be the sufficiently definite entity usually spoken of as a rock-type. The necessity for a given type being once established, and the characters of the type clearly defined, it should receive a name, preferably derived, as is customary, from the type-locality; and thereafter any attempt to alter the definition, or to extend the name beyond it, should be firmly resisted. If this proviso could be secured, the often-heard objection to the multiplication of names would become merely an objection to the increase of knowledge. Concurrently with the settlement of known types and the investigation of new ones, we should expect to gain a clearer insight into their mutual relations from the genetic point of view, and the information thus acquired, in the field as well as in the laboratory, would enable us in due time to group the types into a natural system expressing our knowledge of their chemical, geological, and geographical relationships. In such a system there would be no finality; indeed, its changes would be in some degree a measure of the progress of petrological science. The conception is one far removed from that embodied in the scheme now before us. It is true that a natural and an artificial system might conceivably exist side by side, each being employed for its appropriate purposes. Such a dual classification is evidently contemplated by the authors, when, for instance, they expressly leave the terms 'family' and 'series' free for use in a petrogenetic connection. It is easy to see, however, that the case of petrology differs in fundamental respects from that of botany, and we cannot doubt that the general adoption of a fixed empirical scheme would greatly hinder the development of a natural classification at some future time. Whether the present bold proposal meets in a convenient manner the immediate requirements of petrography is a different question, and one which will find its true answer in the reception accorded to the scheme by the general body of workers.

In conclusion, we may state that the exposition of the system by its inventors leaves nothing to be desired in respect of lucidity and precision. It is reprinted, together with an admirable historical survey of rock-classification by Dr. Whitman Cross, from the Journal of Geology. The volume contains certain additions, including a useful glossary, which inspires the reflection that compositors and proof-readers will not be among those who welcome the new terminology. The book seems, however, to be carefully corrected, and is brought out in a form which fully maintains the reputation of the University of Chicago Press.

A. H.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—February 20th, 1903.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

ANNUAL GENERAL MEETING.

The reports of the Council and of the Library and Museum Committee for the year 1902, proofs of which had been previously distributed to the Fellows, were read. After premising that the Society continues to be generally in a flourishing condition, the Council stated that the number of Fellows had undergone but little change in 1902. The number elected was 48 (4 less than in 1901), of whom 30 qualified before the end of the year, making, with 18 previously elected Fellows, a total accession of 48 in the course of the twelve months under review. During the same period, the losses by death, resignation, and removal amounted to 41, the actual increase in the number of Fellows being therefore 7 (as compared with a decrease of 4 in 1901). The total number of Fellows on December 31st, 1902, was 1,258.

The balance-sheet for that year showed receipts to the amount of £3,439 16*s.* 3*d.* (including a balance of £403 12*s.* 3*d.* brought forward from the previous year), and an expenditure of £3,128 8*s.* 7*d.* (exclusive of the sum of £250 invested in Natal Government 3 per cent. stock).

The issue of the Catalogue of Type and other important Specimens in the Society's Museum, based on Mr. Sherborn's manuscript catalogue, edited and prepared for publication by the Rev. J. F. Blake (to whom the Society are greatly indebted), was also announced.

The reports having been received, the President handed the Wollaston Medal, awarded to Professor Heinrich Rosenbusch, For. Memb. G.S., of Heidelberg, to Professor W. J. Sollas, M.A., D.Sc., F.R.S., for transmission to the recipient, addressing him as follows:—Professor Sollas,—

No man has exercised a greater influence on the progress of petrological science than Professor Rosenbusch. Though a master of detail, he has always insisted on the important bearing of microscopical studies on many of the great theoretical problems of modern geology.

In his celebrated researches on the Steigen Schiefer he combined stratigraphical, mineralogical, and chemical data in such a manner that his memoir must for all time remain a classic in geological literature. His subsequent work is all of the same philosophical character, and every question that he has handled has been fundamentally modified and notably advanced as the result of his investigations. The fertility which he has shown, in the production of new and often profound theories, has only been equalled by the courage with which he has discarded the old so soon as they have proved unsatisfactory or incomplete.

The successive editions of his great work on the microscopic characters of minerals and rocks have been landmarks in the progress of the science. The range of his knowledge therein revealed is enormous, yet we never feel that his writings are overburdened with detail, because of the power of philosophical generalization with which he marshals his facts, and reduces the whole to a consistent and well co-ordinated unity.

As a teacher Professor Rosenbusch has especially excelled, and the devotion and enthusiasm both of himself and his pupils have greatly helped to awaken the interest of geologists in petrological investigations, and to give to these investigations the prominent position that they now occupy.

The Council of the Geological Society make the award of their Wollaston Medal to Professor Rosenbusch in grateful appreciation of these pre-eminent services to geological science.

Professor Sollas, in reply, read the following letter which had been forwarded by the recipient:—Mr. President,—

"Although the Geological Society, for many years past, has accustomed me to a most benevolent judgment of my scientific work, I feel greatly surprised by the award of the Wollaston Medal, the highest honour which the Council of this illustrious Society can bestow. I beg to offer my cordial thanks for this distinction, which I thought far beyond the limits of my aspirations.

"I may proudly confess to have passed a life of earnest and unceasing endeavour in the attempt to understand and to decipher those grand and mysterious documents, wherein the geological history of our mother Earth has been written down by Nature itself; but I am fully aware of the insignificance of the results obtained. Every word which it is our good fortune to decipher involves a new riddle, and so I daily repeat the first scientific experience of my infancy—that the art of spelling is a most difficult one.

"There are many members in this illustrious corporation to whom I owe a vast debt of scientific information and of personal encouragement. The high honour received at their hands on this day will be a stimulus to me for ever-renewed attempts to proceed on my onward way, *γηράσκω δ' αἰεὶ πολλὰ διδασκόμενος*. It will be, indeed, a great satisfaction to me, if the rest of my life's work prove not unworthy of the approbation of this ancient and renowned Society."

The President then presented the Murchison Medal to Dr. Charles Callaway, M.A., addressing him in the following words:—Dr. Callaway,—

Your work among the ancient rocks of Shropshire—Murchison's classical county—commenced as early as 1874, when you brought before this Society evidences of the occurrence of Tremadoc fossils in the so-called 'Bala' rocks of that area; but your conclusions were then in advance of the times. In your second paper, published in 1878, on a "New Area of Cambrian Rocks in Shropshire," however, you not only demonstrated by means of the abundance of fossils the accuracy of those conclusions, but you made that paper the starting-point of what, as afterwards carried out by yourself and others, has effected almost a revolution in our previous knowledge of much of the older half of Shropshire geology.

You first suggested in that paper the Archæan age of the Wrekin volcanic series, and in several subsequent papers you not only showed the extension of these volcanic and Cambrian rocks into the Caradoc area and elsewhere, but introduced into the geological literature of our older rock-groups the names Uriconian, Longmyndian, and Malvernian.

Your researches also in the Malvern Hills, in Anglesey, and in the complicated Assynt and other regions of the North-Western Highlands were all of them most fruitful in discovery, and stimulated the work of others in no ordinary degree. And of your later researches into the obscure phenomena of the crystalline and metamorphic rocks, much the same may be said. As one of those who have followed your track to their great comfort and benefit, and as one who has for more than thirty years been honoured by your friendship, it is a great pleasure to me to be permitted to hand you this Medal on behalf of the Council of the Geological Society.

Dr. Callaway replied as follows:—Mr. President,—

I am deeply sensible of the honour conferred upon me by the award of this Medal. It is to me a special gratification that it bears the name of Murchison, for the greater part of my work has been on ground rendered classic by his genius. We honour him as one of the chief of those who laid the foundations of our knowledge of the oldest rocks, and I am proud to have been able to add a few stones to the superstructure. That I receive this distinction at your hands is a peculiar pleasure. You also have laboured long in the field of Archæan and Proterozoic geology. Your kind and generous appreciation has, therefore, a personal as well as an official value.

In presenting the Lyell Medal to Mr. Frederick William Rudler, late Curator of the Museum of Practical Geology, Jermyn Street, the President addressed him as follows :—Mr. Rudler,—

Our science demands for its progress not only men who discover new facts, but also men who will explain and illustrate its facts and theories to those who are anxious to understand and to make use of them. There are few among those who have been both learners and workers in the science during the last thirty years who do not retain grateful memories of the instruction and assistance which at one time or another you have personally afforded them.

Further, our science needs for its appreciation by the economic world and the public those who, being familiar with the facts already gathered together, will present them in a clear and convincing form, and expound their practical applications. In this respect also you have done our science lasting service. Indeed, your long official career at the Museum of Practical Geology has been a record of unselfish devotion to the advancement of the practical and educational sides of geology.

In countless ways—in reviews, in the later editions of Ure's famous "Dictionary of Arts, Manufactures, and Mines"; in your masterly essays on "Experimental Geology," and on "Fifty Years' Progress in British Geology," delivered as Presidential Addresses before the Geologists' Association—not to mention anthropological and other addresses,—you have given evidence of your wide knowledge of the literature and substance of geology and the allied sciences, of your sound judgment, and of your exceptional capacity for transmitting to others the accurate knowledge which you possess.

It affords, therefore, to the Council of the Geological Society the greatest satisfaction to award to you the Lyell Medal, which, according to the words of its founder, is to be given to one who "has deserved well of the science."

Mr. Rudler replied in the following words :—Mr. President,—

To have the privilege of standing here as the recipient of a Medal is a far higher honour than I had ever dared to expect. While acknowledging most gratefully, though I feel most inadequately, the generous action of the Council in making this award, I am also anxious to express my deep sense of indebtedness to you, Sir, for the very indulgent words with which you have been so good as to enrich this presentation. If anything like personal detachment from such an award were permissible, I should like to be allowed to regard this as a token of sympathy between this Society and the institution with which I was so long connected, and where the ruling desire of every officer is—if I may use the words of the illustrious founder of this bequest, which you have just quoted—to deserve well of geological science. It is, Sir, a matter of extreme gratification to me that I should find myself unexpectedly honoured by the possession of a Medal founded by our great master, whom it was my privilege to know personally, and whose memory I so profoundly revere.

The President then presented the Bigsby Medal to Dr. Henry M. Ami, M.A., of the Canadian Geological Survey, addressing him as follows :—Dr. Ami,—

The members of the Geological Society who interest themselves in the Palæozoic formations of Britain and America, are well aware of the extent and importance of your work among the Palæozoic rocks and fossils of Canada. As Assistant-Palæontologist to the Canadian Survey, you have not only been for many years responsible for much of the classification and tabulation of the Lower Palæozoic fossils in the Museum of that Survey, but you have visited the places where they were collected in the field, and identified on the spot their local horizons. This two-sided knowledge has enabled you in several of your papers, such as those bearing on the "Geology of Quebec and its Neighbourhood," the "Utica Terrane," and the "Organic Remains and Geological Formations of the Eastern Townships," to throw much light on disputed questions of succession and stratigraphy.

Nor has your work been restricted to the older Palæozoic rocks. Your papers on the "Knoydart Formation of Nova Scotia," the "Carboniferous Formations of

Canada," etc., have done much to clear up the difficulties of the correlation of these formations with those of other countries. Neither must we forget the many papers in which you, with fulness of knowledge and great depth of sympathy, have laid before geologists and the public the lives and labours of those great pioneers who have accumulated the vast store of knowledge which we now possess of the rocks and fossils of the Dominion.

As an old friend and correspondent of yours, I am very pleased that it has fallen to my lot to hand you this Medal; and I can assure you, on behalf of the Council of the Geological Society of London, that it is a special gratification to them to award it to one whose work has been done in the country of the founder of the Medal himself, and among the rocks and fossils studied by him.

Dr. Ami replied in the following words:—Mr. President,—

I am deeply sensible of the great honour which the Council of this Society has conferred upon me. Especially am I gratified in receiving this award at the hands of one who has been so generous a counsellor and critic in matters geological for the past eighteen years. Words fail me to express in adequate terms the gratitude which fills me at present. Suffice it to say that, through the liberality of the Canadian Government and courtesy of the Hon. the Minister of the Interior (Mr. Clifford Sifton), Head of the Geological Survey Department at Ottawa, I have acceded to his wishes, and come over in person to receive at your hands the award so generously made.

It is always a source of inspiration to come to London, the centre of thought, the fountain-head of research, and radiator of power; and, believe me, that, combined with the pleasure and privilege of attending one of the anniversary meetings of this Society, of which I have been a humble Fellow for some eighteen years, there lurked in my mind the thought of gain in valuable information during my stay, which I know will enable me all the better and more intelligently to carry out the special work on the Silurian faunas and succession of Eastern Canada which has been entrusted to me.

That my name should become associated with that of the late Dr. Bigsby, founder of the Medal, is a matter of which I have great reason to be proud. Bigsby was a pioneer in British North American geology. It has been my lot and good fortune recently to collect all the data relating to the geological history of the Grand Manitoulin and adjacent islands of Palæozoic age in the Lake Huron district of Canada, and it may not be uninteresting to state here that, when the unexpected news of this award reached me in Ottawa, I had then completed, and on my desk, a synopsis of Dr. Bigsby's geological explorations in that region during the early years of the last century.

In conclusion, permit me to add that I am deeply moved at this moment by the thought of what the acceptance of the Bigsby Medal on my part involves. There is undoubtedly associated with it a solemn pledge and obligation to prosecute geological research-work still farther. If I am spared, Sir, it will be my highest endeavour as well as pleasure and privilege to follow in the footsteps of those eminent geologists in the distinguished list of recipients of the Medal founded through the generosity of the late Dr. Bigsby, and prove not unworthy of the marked distinction that the Council have conferred upon me this day.

The President, in handing the Prestwich Medal, awarded to John, Baron Avebury, P.C., F.R.S., to Professor T. G. Bonney, D.Sc., F.R.S., for transmission to the recipient, addressed him in the following words:—Professor Bonney,—

Sir John Lubbock, now the Right Hon. Lord Avebury, P.C., became a Fellow of this Society in 1855. He was one of those who took a warm interest in the question of the antiquity of man, in those early days when it was so much in dispute. He did much to support the new views, not only by a paper in the Natural History Review, but also by his work on "Prehistoric Times," in which that paper was subsequently incorporated. In those days he was closely associated with Sir Joseph Prestwich (who at that time had not yet been called to the professorial chair at Oxford), and, along with Sir John Evans, frequently accompanied him and other Fellows of the Society on geological excursions in France and elsewhere, investigating not only the evidences of the antiquity of man, but other problems of special interest in geology.

Since then, notwithstanding his numerous public avocations, his important business occupations, and his researches in natural history, both entomological and botanical, he has always retained a lasting attachment to geology. He has evinced this, not only in keeping abreast with its progress and accompanying its workers in the field, but also in the publication of works on geology, marked by his own literary charm. His recent works on the scenery of Switzerland and of England have done much to create a deep appreciation and sympathy for the science among the thinking and educated public.

Whether, therefore, from old associations, or from the special nature of his geological researches, or from the fascination of his geological works, the Council of the Geological Society feel that he is a most fitting recipient of the first gold medal struck in accordance with the testamentary dispositions of our venerable Fellow, Sir Joseph Prestwich.

Professor Bonney, in reply, read the following letter which had been forwarded to him by the recipient:—Mr. President,—

"I should have felt it a great compliment in any case that the Geological Society should have bestowed upon me one of their medals, but I am specially gratified to have received the first of the Medals instituted in honour of my old friend Sir Joseph Prestwich. It is now more than forty years since I first visited the valley of the Somme under his guidance and that of M. Boucher de Perthes. Since then I have had the advantage of making many most instructive excursions with him. On those occasions we were out early and late. Meals constantly gave way to gravel-pits. On one occasion I spent a week with him in Paris—at least, if we can be said to have been in Paris, when I think that we were never there between 7 o'clock in the morning and 8 in the evening; and I look back on those expeditions with the greatest interest. I shall value the Medal extremely, both as a mark of the approval of the Council, and also in memory of one whom I esteemed so highly, and to whom I owed so much. It is a matter of great regret to me that absence from England has precluded me from attending to receive it personally."

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Mr. L. L. Belinfante, M.Sc., Assistant Secretary of the Geological Society, addressing him as follows:—Mr. Belinfante,—

At a meeting of Fellows of the Geological Society it is quite unnecessary for me to say anything as to your merits. You stand here among friends and well-wishers, to all of whom you are well known as the capable Assistant Secretary of the Society. But perhaps it is to the Council alone, and more particularly to those who have served as officers, that the full extent of the indebtedness of the Society to you is known. You combine the offices of Assistant Secretary, Clerk, Librarian, Editor of the Journal, and Curator of the Museum, and each of these offices, whether the duties are performed by you personally or under your general supervision, are filled to the great advantage of the Society. Authors of papers owe you a deep debt of gratitude for the help that they have received from you in editing their papers; indeed, such trust have they in your judgment that they are almost too liable to leave the whole of the burden of seeing their papers through the press in your hands.

If it were necessary for me to allude to actual geological work done by you, I have only to mention the Index to the first Fifty Volumes of the Quarterly Journal, which was completed by you outside your official hours, and has proved of immense value to all writers in geology. But in handing you this award of the Wollaston Donation Fund, I trust rather that you will receive it as a mark of appreciation by the Council and Fellows of your able and conscientious services to the Society and to geology as Assistant Secretary and Editor of the Journal, and I can only conclude with the hope that we may have the advantage of your services for many years to come.

The President, in handing the Balance of the Proceeds of the Murchison Geological Fund, awarded to Mrs. Elizabeth Gray, of Edinburgh, to Dr. Henry Woodward, F.R.S., for transmission to the recipient, addressed him in the following words:—Dr. Woodward,—

Mrs. Gray has devoted the leisure hours of nearly half a lifetime to collecting in the field and arranging in her cabinets the fossils of the Ordovician and Silurian rocks of the Girvan district of Ayrshire. The palæontology bears so closely on the structure of this complicated region, that a detailed knowledge of it is indispensable to any geologist who attempts to unravel that structure.

Her collections have been of more than ordinary value, because of the careful record that she has kept from the first of the exact locality and horizon at which each fossil was collected. She has generously placed her specimens at the disposal of all geologists and palæontologists engaged in the study of the Palæozoic rocks and fossils, and a large number of them have been described in the monographs of Davidson, Nicholson, Etheridge, and others. When working in the Girvan district, the officers of the Geological Survey of Scotland checked their own collection by that of Mrs. Gray, and paid a well-earned tribute to its value by publishing in their memoir on the Silurian Rocks of Southern Scotland a full list of all her fossils supplementary to their own. My own personal indebtedness to the collections made by Mrs. Gray and her family, when I was working at the geology of that district, was especially great; and it affords me no ordinary gratification to be able to hand to you, for transmission to her, the Balance of the Proceeds of the Murchison Geological Fund, on behalf of the Council of this Society.

Dr. Woodward, in reply, read the following letter which had been forwarded to him by the recipient:—

"Dear Dr. Woodward,

"I am gratified to learn that you intend to be present at the anniversary meeting of the Geological Society, and I thank you for your kindness in allowing me to nominate you to receive for me on that occasion the Murchison Fund, awarded by the Council of the Society in consideration of what they too generously characterize as 'great services to Geological Science.'

"My work in the Girvan district, among the fossils of the Silurian rocks, has been to me a lifelong pleasure, augmented of late years by the knowledge that my collection has proved of service to the Geological Survey of Scotland, as well as to individual geologists—to name among these but the late Dr. Thomas Davidson.

"It is incumbent on me, however, to record that my husband, the late Mr. Robert Gray, taking a keen interest in my pursuits, shared with me during many years the agreeable task, not only of searching for fossils, but of helping to work them out when found, so that it is difficult for me, in the present circumstances, to repress a pang of regret that he cannot likewise participate in my satisfaction at the Geological Society's very gracious recognition of what, to some extent, was our joint work.

"I value very highly the honour conferred upon me, and beg you to convey to the Council my grateful thanks and sincere acknowledgments."

The President then presented part of the Balance of the Proceeds of the Lyell Geological Fund to Mr. George Edward Dibley, addressing him as follows:—Mr. Dibley,—

You have, for a number of years, devoted the leisure hours of a busy life to the careful collecting of fossils from the Chalk, and have thereby added much to our knowledge of the distribution of species in the several life-zones. The results of these labours have been partly published in the Proceedings of the Geologists' Association, and they include the record of the discovery of a specimen of especial interest, as it is believed to be a representative of the lizard-like Rhynchocephalia, no example of which has been previously recorded from the Chalk.

I have much pleasure in handing to you a moiety of the Balance of the Lyell Fund, which has been awarded to you by the Council of this Society.

Mr. Dibley replied in the following words:—Mr. President,—

I beg to thank the Council of the Geological Society most heartily for their kind appreciation of my efforts to further the accurate knowledge of our Cretaceous geology by the systematic and patient collecting of fossils zone by zone, a method of research so clearly demonstrated by you, Sir, in the older Palæozoic rocks. I can assure you that it is a delight to me to be able to devote each week-end to this branch of natural science; and I only trust that I may be spared to continue my labours on new ground as well as on the old, so that I may be of further use in promoting the advance of geological science.

I may perhaps be allowed to add that, in thanking you for this honour conferred upon me, it gives me especial pleasure to receive it at your hands.

The President, in handing the remainder of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Mr. Sydney S. Buckman, to Dr. Bather, M.A., for transmission to the recipient, addressed him in the following words:—Dr. Bather,—

In the year 1897 the Council of the Geological Society awarded to Mr. Buckman the proceeds of one of their Funds, in acknowledgment of the important work which he had already accomplished among the Jurassic Invertebrata, and of his investigations into the stratigraphical details of their containing formations, expressing their confidence that he would be certain to continue and extend that work.

Their confidence has been more than justified; for since that time, not only has he issued important supplements to his Monograph on the Inferior Oolite Ammonites, published by the Palæontographical Society, and continued his stratigraphical studies on Dundry Hill, and on the Bajocian and Contiguous Deposits in the Northern Cotteswolds, but he has broken new ground in his memoir on "Homœomorphy among Jurassic Brachiopoda," that will doubtless have far-reaching results. He has also published interesting and suggestive papers upon river-development, especially with regard to the genesis of the Severn and the Wye.

For a quarter of a century he has devoted his energies and genius to the advance of geology and palæontology, and each year he has presented to science something valuable and original. The Council of the Geological Society, while sensible of the inadequacy of this recognition of his labours, hope that he will accept it as an earnest of their appreciation of his scientific work.

Dr. Bather, in reply, said:—Mr. President,—

In receiving this award on behalf of my friend Mr. Buckman, it had not been my intention to depart from the precedent that commends silence to the recipients of funds as the most suitable expression of their gratitude; in fact, I took care to leave at home the speech he wrote out for me. But since this somewhat recent precedent has twice been broken this afternoon, I might seem wanting, both in courtesy to yourself and in loyalty to Mr. Buckman, if I did not give the gist of his remarks.

Mr. Buckman is aware that his palæontological work, especially that relating to Ammonites, has met with considerable criticism. He is therefore particularly grateful for this recognition on the part of the Council of the Geological Society. The principles that have animated his work on the Ammonites have been applied by him also to the Brachiopods. They are, in fact, principles that are working a vast revolution in the whole of palæontology. The interpretation of the phenomena of homœomorphy—that is to say, the appearance of species, often at different periods, perplexingly similar in outward form though descended from different stocks—will lead to much more exact identification of fossils. This preciser palæontology, in conjunction with field-work among the Secondary rocks on the lines indicated in Mr. Buckman's last paper contributed to this Society, will, he is confident, have a distinct practical value, since it is bound to throw light on the position of concealed coal-basins. Unfortunately, such wealth as may be obtained in consequence of this purely scientific research will, under present laws, fall not to the nation but to landowners; least of all will the students, to whose researches it is due, receive any material benefit—except, perhaps, such an award as this, for which I have to offer to you, Sir, Mr. Buckman's sincere thanks.

The President then proceeded to read his Anniversary Address, in which he first gave obituary notices of several Fellows deceased since the last annual meeting, including the Rev. Professor T. Wiltshire (elected a Fellow in 1856), Dr. A. R. C. Selwyn (elected in 1871), Mr. J. C. Mansel-Pleydell (el. in 1857), Mr. W. H. Penning (el. in 1868), Mr. W. Gunn (el. in 1876), Mr. J. Macpherson (el. in 1890), Mr. A. Vaughan Jennings (el. in 1891), Mr. J. Landon (el. in 1887), Mr. A. L. Collins (el. in 1892), Major J. W. Powell, Foreign Correspondent (el. in 1892), Mr. A. Hyatt, Foreign Correspondent (el. in 1897), Lord Pirbright (el. in 1861), Mr. F. Stevenson (el. in 1877), and Dr. Hugh Exton (el. in 1883).

He then dealt with the relation of geology to its fellow-sciences. Astronomy and geology—one the oldest, the other the youngest of the sciences—have both a comparatively small number of adherents and working members. One suggests to the mind of man ideas of infinity, and the other those of eternity; but while the former ideas have found ready acceptance, the latter have had to struggle against much reluctance on the part, not only of the average man, but of physicists and mathematicians, and even of geologists themselves, and this in spite of the fact that some of the most fertile principles of geological science have had their spring in a conviction of the immensity of past time.

Geology has relations with mineralogy, physics, geography, and biology; but though fearlessly acknowledging how much it has borrowed from each of these sciences, it can claim that the debt has in every case been repaid with interest. To mineralogy it has given the associations and relations of minerals in the crystalline rocks; to biology, the strongest proofs of organic evolution and the stages of its advance; to geography, the explanation of the origin of the earth's surface-features, and the foundation of the study sometimes called 'geomorphology'; to physics, the facts with regard to the deformations of the earth's crust, which still await a theoretical explanation.

The study of geology shows that the corporate geological organism has three necessary functions—research, practice, and education. So long as all three functions are naturally and healthfully performed, so long will geology live and flourish. The work and influence of Werner and De la Beche show that the progress of the science is at its swiftest and surest when none of the three functions suffer from disuse.

In its relations to the thoughts of mankind and ideas of life, what gives character and its especial colour to the science of geology is that it is the exponent, or practically the discoverer, of the idea of continuous evolution, "for he discovers who proves." To a student who has gone through a geological training and appreciated its meaning, the idea of slow and continuous evolution becomes part and parcel of his mental constitution, and he carries this conception into his other studies. In all cases he is on the watch for those simple natural causes that are capable of the present accumulated effects; he is watching the development of a living being growing up, as it were, before his mental vision. It is therefore to be desired that some knowledge of this kind should reach the ordinary man of education and leisure, as well as the specialist, for it tends to restore the loss of balance due to the self-absorptive and introspective tendency of much of our present-day culture.

Some such geonomic training or earth-knowledge is essential in any complete scheme of education—at first hardly differentiated into geology and geography, but later passing on to the study of topography, geography, and geology. The training should be in the early stages experimental and practical, bringing out all that can be shown upon maps and learnt from them; but the didactic side must not be neglected, particularly in those years of life when a student is most qualified to profit by it, because the facts of science are so many, and the grandest conclusions are so dependent on the higher stages of knowledge.

The veil of ignorance and of traditional opinion which hid from the view of the Middle Ages the wonders which geology has since revealed, was so opaque that, until the close of the eighteenth century, no light could penetrate beyond. But so old and flimsy was it that, when once the strong hand of the geologist had torn it, it was rent from top to bottom, and in the flood of light which entered discovery followed discovery in endless succession. These discoveries have benefited not only geology but all its fellow-sciences, and have been of supreme importance to man himself.

Therefore, as geology goes hopefully forward into the new era now opening out before it, its students should never forget that their science is not only the interpreter of Nature, but also the servant of Humanity.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* The Right Hon. Lord Avebury, P.C., D.C.L., LL.D., F.R.S., F.L.S.: F. A. Bather, M.A., D.Sc.; W. T. Blanford, LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; Professor E. J. Garwood, M.A.; Sir Archibald Geikie, D.Sc., D.C.L., LL.D., F.R.S. L.&E.; Professor T. T. Groom, M.A., D.Sc.; Alfred Harker, Esq., M.A., F.R.S.; R. S. Herries, Esq., M.A.; R. Logan Jack, LL.D.; Professor J. W. Judd, C.B., LL.D., F.R.S.; Percy F. Kendall, Esq.; Professor Charles Lapworth, LL.D., F.R.S.; Lieut.-General C. A. McMahon, F.R.S.; J. E. Marr, Esq., M.A., F.R.S.; Professor H. A. Miers, M.B., F.R.S.; H. W. Monckton, Esq., F.L.S.; E. T. Newton, Esq., F.R.S.; G. T. Prior, Esq., M.A.; Professor H. G. Seeley, F.R.S., F.L.S.; Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; J. J. H. Teall, Esq., M.A., F.R.S.; Professor W. W. Watts, M.A.

Officers:—President: Prof. Charles Lapworth, LL.D., F.R.S. *Vice-Presidents:* Sir Archibald Geikie, D.Sc., D.C.L., LL.D., F.R.S. L. & E.; Professor H. A. Miers, M.A., F.R.S.; E. T. Newton, Esq., F.R.S.; and J. J. H. Teall, Esq., M.A., F.R.S. *Secretaries:* R. S. Herries, Esq., M.A., and Professor W. W. Watts, M.A. *Foreign Secretary:* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer:* W. T. Blanford, LL.D., F.R.S.

The thanks of the Fellows were unanimously voted to the retiring Vice-Presidents, Mr. J. E. Marr and Professor H. G. Seeley; and to the retiring Members of Council, Mr. W. H. Hudleston, the Right Rev. John Mitchinson, Dr. D. H. Scott, Mr. A. Sopwith, and Dr. Henry Woodward.

II.—February 25th, 1903.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Occurrence of *Dictyozamites* in England, with Remarks on European and Eastern Floras." By Albert Charles Seward, Esq., M.A., F.R.S., F.L.S., F.G.S., Fellow of Emmanuel College, Cambridge.

The specimens described as a new species of *Dictyozamites* were obtained from a bed of ironstone, low down in the Estuarine Series, on the northern face of the Upleatham outlier, near Marske-by-the-Sea, by the Rev. John Hawell, F.G.S. The genus is also found in the Rajmahal Series of India, in Central Japan, and at Bornholm. Its probable taxonomic position is best expressed by placing it as a member of the Cycadophyta.

The author proceeds to a comparison of the Bornholm, Indian, Japanese, and English floras; and as resemblances are masked by the use of different generic or specific names for plants which are either identical or represent closely allied members of the same family, a special list of these floras has been prepared, in which, while the names at present in use are indicated, it is pointed out where obscured identities or resemblances exist. From this comparison the author concludes that there was a greater similarity between the vegetation of Eastern and Western regions, during part at least of the Mesozoic Era, than is usually admitted; while the differences between Mesozoic floras of approximately the same geological age are for the most part slight and unimportant, when their wide geographical separation is considered. Equisetaceous plants are practically ubiquitous; several ferns of apparently the same species occur in the Far East and in Western Europe; cycadaceous plants are represented by cosmopolitan types, and the same may be said of the genus *Araucarites* and other members of the Coniferæ. The most noteworthy exceptions are afforded by the Mesozoic representatives of the two isolated recent ferns *Matonia* and *Dipteris*; these two families—each with a surviving genus—played a conspicuous part in the vegetation of the Rhætic and succeeding Jurassic Epochs in Europe, and to a less extent in North America, but there are no satisfactory records of their existence in India or Japan. A similar state of things is illustrated by the Ginkgoales, the class of which the 'maidenhair-tree' of China and Japan forms the solitary survivor; the abundance of both *Ginkgo* and *Baiera* in the Mesozoic of Europe is in striking contrast to their almost complete absence in India.

2. "The Amounts of Nitrogen and Organic Carbon in some Clays and Marls." By Dr. N. H. J. Miller, F.C.S. (Communicated by Sir John Evans, K.C.B., D.C.L., F.R.S., For. Sec. G.S.)

Analyses of soils are given to show that, under most conditions, decaying vegetable matter in soil tends to become more nitrogenous, on account of the greater ease with which gaseous compounds are formed with carbon than with nitrogen. Hilgard's experiments throw light on the effects of extreme conditions of climate, the amount of soluble humus being much greater in soils in humid than in arid climates; thus, although the total amount of soluble nitrogen does not vary much, the percentage of it in the humus varied very considerably in the two cases. The large areas of peat-land known as 'Hochmoor' contain larger proportions of carbon and nitrogen at depths of 7 and 14 feet than at the surface. The organic matter of soils is of two kinds—the humous portion and the bituminous; the latter being regarded as belonging to the original deposit from which the soil is derived. Analyses of soils and subsoils are given to illustrate this point. Further light on this subject is derived from the analysis of a series of specimens from the following deposits, obtained through the kindness of Sir Archibald Geikie from borings in the possession of the Geological Survey: Lower Lias, Oxford Clay, Kimmeridge Shale, Purbeck and Wealden strata, Gault, Chalk Marl, and London Clay. Apart from the interest due to the great depths from which the samples were obtained, and the evidence which they afford of the enormous accumulations of combined nitrogen, they possess the further and greater value of representing the materials out of which large areas of soils have been derived. Calcium-carbonate varies from 82·1 to 0 per cent., organic carbon from 1·229 to 0·229, and nitrogen from 0·068 to 0·021; the highest proportion of carbon to nitrogen is 40·3 to 1, and the lowest 8·9 to 1. It would be important to determine, in the case of these older deposits, whether any of the organic matter at all is in the form of humus.

III.—MINERALOGICAL SOCIETY, February 3rd.—Professor H. A. Miers, F.R.S., Vice-President, in the Chair. Mr. L. Fletcher gave an account of the fall of a meteoric stone on August 22nd, 1902, at Caratash, Smyrna; and also contributed a note on the history of the mass of meteoric iron found in the neighbourhood of Capera, Patagonia. Mr. H. L. Bowman gave the results of determinations of the refractive indices of pyromorphite and vanadinite by means of artificially ground prisms having an angle of about 30°. For red light the refractive indices of pyromorphite were $w = 2{\cdot}139$, $e = 2{\cdot}124$; and of vanadinite, $w = 2{\cdot}354$, $e = 2{\cdot}299$. Mr. T. V. Barker described quartz crystals of peculiar habit which were collected by Lieut. E. G. Spencer-Churchill near De Aar, South Africa. Two crystals were remarkable as exhibiting faces seldom observed on quartz, one in the zone *mz* and the other in the zone *rz*.

IV. — EDINBURGH GEOLOGICAL SOCIETY. Special Meeting, 5th February, 1903. Dr. Horne, F.R.S., in the Chair. Lecture on "The Fassa-Monzoni District, or Simultaneous Duplex Crust Movements." By Mrs. Ogilvie Gordon, D.Sc., Ph.D., Aberdeen.

The lecture was illustrated by Mrs. Gordon's lantern views, geological maps and sections, rock specimens, and mineralogical slides. In describing the succession of Triassic strata Mrs. Gordon pointed out two distinct advances made by her work—(1) She had discovered the presence of Wengen-Cassian marls with characteristic fossils in the midst of the Middle Triassic limestones, whereas hitherto these fossiliferous marls had been reported to be absent in Fassa; (2) she had determined the presence of a definite band of fossiliferous marls and crinoidal and oolitic limestones between the Lower and Middle Trias, as a constant member in all undisturbed sections. Hitherto these limestones had been regarded as unfossiliferous, and described as a rarely present, abnormal facies of the lower horizons of Middle Triassic limestones. The establishment of this definite passage zone between Lower and Middle Trias was an important addition to the geology of South Tyrol. Further, it corresponded to the horizon of 'Reichenhall limestone' and the 'Myophoria beds' in North Tyrol, and probably also to the well-known 'Röth' horizon in the North German Trias. Throughout the Tertiary crust movements in the Alps this passage zone had been the great crush-zone of the district. It occurred in Fassa below a massive development of calcareous rocks, and above an almost equal thickness of mixed deposits; it was therefore a well-marled 'critical' zone within the earth's crust, interleaved between rock material, presenting strongly contrasted physical characters. The maximum deformational effects had been attained at this zone, and in the other leading 'critical' zone presented by the Wengen-Cassian marls. Innumerable planes of overthrust and downslip had developed within these bands, some with only 10 degs. to 20 degs. inclination, others much steeper. Vast eruptions of molten rock had found their way into these deformational zones, and consolidated in the form of wide sheets and sills at those definite horizons within the Triassic succession. Thus, one of the general results of her detailed survey had been to disprove the previous conception that the porphyrite rocks in Fassa had originated as surface outflows in Triassic time, and to show that they had been intruded into the local fault lines and planes of crust deformation which developed during middle and late Tertiary Alpine movements. A similar result had been obtained several years ago by her for the area on the north. The previous investigators had failed to recognize the presence of the innumerable crust planes with extremely low inclination, and consequently overlooked the correlation of the igneous invasions with pre-existent deformational structures. After indicating on the map the complete sequence of the igneous rocks at Monzoni, Mrs. Gordon proceeded to describe her new results regarding cross-fold formation. Several folding movements had affected this district. In the first place, undulations directed east and west had formed with a steep southern face and a long northern slope, the width of an undulation being about 4½ miles. These had been deformed by oblique cross-folds, which developed simultaneously along two directions, E.N.E.–W.S.W. and W.N.W.–E.S.E. During these movements the steep south faces of the original plications were overthrust towards S.S.E. and S.S.W., and the first inrush of molten rock occurred into zones of crust attenuation and fracture. Still later, another duplex system of cross-folds was superinduced rectangularly upon the earlier in N.N.W.–S.S.E. and N.N.E.–S.S.W. directions. Overthrusts and shear-slips took place again, and fragmented the previous thrust masses and igneous intrusions. Mrs. Gordon showed by reference to her map that the most intense effects of crust deformation had been coeval with this advanced stage in the superposition of duplex deformational systems upon the original and fundamental east-west undulations. A subsequent epoch of crust adjustment and surface erosion had ensued, characterized by local subsidences taking place pre-eminently along the previous crust fractures. Local crumplings had then occurred around large masses of igneous rock or the larger deformation fragments of Triassic limestone. Small igneous intercalations of highly differentiated rock materials accompanied these inthrows. Mrs. Gordon's interpretation of this remarkable series of cross-folds was based upon the principle of the simultaneous action of paired resultant strains, acting along N.E.–S.W. and N.W.–S.E. directions, the precise directive angle varying in proportion as the east-west or the north-south stresses due to crust compression were the more powerful, and also in accordance with particular local modifications of the regional strains. At the close a vote of thanks was cordially given to Mrs. Gordon.

CORRESPONDENCE.

EOLITHS FROM SOUTH AND SOUTH-WEST ENGLAND.

Sir,—Kindly insert the following correction and addition to my paper on "Eoliths from South and South-West England" in the March number.

1. *Corrigendum.*—Instead of Bat's Corner read *Kettle's Corner*, Parsonage Farm (Chapel Croft Field), near Ash. Mr. Harrison informs me that it is so marked in the 6 inch map of the district. Bat's Corner was the name given me on December 24th, 1894, when I visited the pit with Mr. Harrison, but as tenants change so do the names of their farms. Probably Kettle was the name of a former tenant.

2. *Addendum* (*Bibliography*), with sincere apologies for the omission.

1899. *Newton, E. T.*—Presidential Address to the Geologists' Association, February 5th, 1897: Proc. Geol. Assoc., vol. xv, pp. 69–72.

1902. *Haddon, A. C.*—"Early Man and his Life," third paper: National Home Reading Union Magazine, p. 45.

Pyrford, *March 6th*, 1903. R. Ashington Bullen.

THE ORIGIN OF THE ARCHÆAN ROCKS.

Sir,—Some references to the Archæan rocks made by Mr. G. W. Bulman in the Geological Magazine for March (p. 126) call for a word of comment. I do not understand what he means by "pre-Archæan deposits." There are no rocks older than the Archæan, whether we use the term as equivalent to "pre-Cambrian" or limit it to the "Fundamental Complex." Then he remarks that "Geologists are yet sorely perplexed with the problem of the Archæan rocks. They have not yet decided whether they are metamorphosed ordinary sediments, [or ?] part of the original solidified crust of the earth, or chemical precipitates from a hot primitive ocean." But these alternatives are *not* the problem. There is no perplexity whatever about a large proportion of the Archæan rocks. The Longmyndian and Torridonian are known to be mainly sedimentary; the groups identified as Pebidian, Uriconian, and Charnian are known to be predominantly volcanic; and the rock-masses called Malvernian and Hebridean are generally admitted to be igneous plutonics. A similar variety of origin has also been ascertained with respect to many of the Archæan rocks of North America, Bohemia, and elsewhere. There are, of course, some Archæan rock-groups whose genesis has not yet been determined with certainty; but these are only a *part* of "the problem of the Archæan rocks." C. Callaway.

Cheltenham, *March 5th*, 1903.

FLINT IMPLEMENTS FROM THE FAYUM, EGYPT.

SIR,—I have read with great pleasure the paper by Mr. Hugh J. L. Beadnell, in the February number, on "Neolithic Flint Implements from the Northern Desert of Fayûm, Egypt."

I was in Egypt last year, and brought home a collection of flints from the Fayum and other districts. I bought my Fayum specimens from the Arabs. The principal locality was Kasr Qurum. I have all the types figured by Mr. Beadnell except Plate IV, Fig. 2, and many not figured by him.

My specimens are all of the finest workmanship, the production of a race who could only have attained to this degree of perfection after a long period. I have also a number of 'wideners' from 4 to 6 inches long, of exquisite workmanship, and mostly for left-handed boring.

I have, however, a number of implements of entirely different types, formed of an impure sort of chert or quartzose flint; these are deeply patinated, and weather-worn to an extent I have never seen in flints of any kind, not even eoliths. They are probably of early Neolithic age, before man had acquired the art of putting a keen, sharp edge on his implements. JAMES NEILSON.

MILNBANK HOUSE, DENNISTOUN, GLASGOW.

OBITUARY.

DR. HUGH EXTON, F.G.S.

DR. HUGH EXTON, F.G.S., was President of the South African Geological Society at Johannesburg from its commencement in 1895; but in December, 1902, retired from the chair on account of ill-health, and died 7th January, 1903. His exertions whilst serving as Medical Officer to H.M. troops during the late war, and afterwards in military camps at Ladysmith and Harrismith, seriously affected his health; and we learn that the meeting of the Society in the second week of January, 1903, was postponed in respectful consideration of his death at the time. He had retired to King William Town, British Kaffraria, on his resignation. Dr. Exton was elected a Fellow of the Geological Society of London in 1883; he presented a collection of the Auriferous Conglomerate of the Witwaters Rand, with a note and plan, in 1899 (see Quart. Journ. Geol. Soc., vol. xlvi, Proc., pp. 3 and 4). In 1901 he communicated to the GEOLOGICAL MAGAZINE, November and December, pp. 509 and 549, some interesting notes on the geology of the neighbourhood of Ladysmith, and further notes on the geology near Harrismith were expected.

FREDERICK WILLIAM JUSTEN, F.G.S.—We deeply regret to record the death of Mr. F. W. Justen, only son of Mr. Frederick Justen, F.L.S. (Dulau & Co.), our publisher. Mr. Justen, who died on March 16th at the early age of 42 years, was an expert in scientific literature, and his loss will be severely felt by his father and his many friends.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. V.—MAY, 1903.

ORIGINAL ARTICLES.

I.—WOODWARDIAN MUSEUM NOTES: BRACHYMETOPUS STRZELECKII, McCOY, 1847.

By F. R. COWPER REED, M.A., F.G.S.

THE genus *Brachymetopus* was founded by McCoy in 1847,[1] and the generic characters were drawn from the Australian species *Br. Strzeleckii*, McCoy, which was at the same time described. The specific characters of this form were very briefly given, the leading features having been mentioned in the diagnosis of the genus. Dr. Henry Woodward[2] in 1884 gave a new summary of the generic characters differing somewhat from that originally furnished by McCoy, being modified in such a way as to include the European or British species, *Br. ouralicus*, De Vern., *Br. Maccoyi*, Portl., *Br. discors*, McCoy, and *Br. hibernicus*, Woodw. The original type-specimens of *Br. Strzeleckii* used by McCoy (op. cit.) in drawing up the description of the genus, and figured by him at the same time, are in the Woodwardian Museum, to which they were presented in the year 1844 by the Rev. W. B. Clarke. They come from the Carboniferous Shale of Dunvegan, New South Wales.[3] The specimens comprise three complete head-shields, two of which are hollow impressions and one a cast, and portions of three or four others; there are also three casts of complete pygidia, one perfect impression, and fragments of two others. This material demands a fuller description of the specific characters than McCoy furnished, particularly as this type-form of *Brachymetopus* shows features differing in several respects from those of the better known European species ascribed to the same genus. McCoy's description (op. cit.) of the species was as follows :—"Glabella widest at the base, with one very minute, obscurely marked, cephalothoracic furrow at the base on each side; all the segments of the pygidium with an irregularly tuberculated ridge along the middle; lateral segments forming large tubercles where they join the thickened limb, opposite each of which is a short slender spine projecting from the margin."

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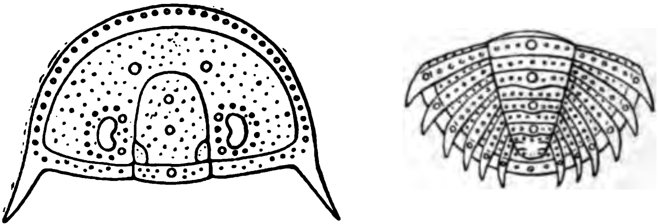
[1] McCoy: Ann. Mag. Nat. Hist., xx (1847), p. 229, pl. xii, figs. 1*a*, 1*b*.

[2] Henry Woodward: Mon. Brit. Carb. Trilob. (Palæont. Soc.), 1884, p. 46.

[3] The plants in this collection have lately been re-described by Mr. E. A. Newell Arber, Q.J.G.S., lviii (1902), pp. 1–26.

This description may be amplified as follows (using only the type-specimens):—Head-shield semicircular, moderately convex, with strong raised rounded border increasing slightly in width towards the front, and separated off by a deep furrow. Genal angles furnished with slender divergent smooth spines, less than half the length of the head-shield. Neck-segment strong, marked off by deep furrow. Glabella convex, subcylindrical, about twice as long as wide, and measuring about one-fourth the width and two-thirds the length of the head-shield. At its base is a pair of small nodular basal lobes, in most specimens quite inconspicuous. Two large tubercles are situated in a line down the middle of the glabella, followed by a similar median one on the occipital segment. Occipital segment strong, rounded, separated off by deep furrow. On cheeks at anterior end of glabella is a pair of large tubercles, one on each side.



1 2

Brachymetopus Strzeleckii, McCoy.

Fig. 1, the head-shield, and Fig. 2, the pygidium (restored). Restorations founded on the type-specimens. Enlarged about 8 times natural size. Carboniferous Limestone: New South Wales.

No facial sutures visible. Eyes prominent, reniform, less than half the length of the glabella, distant from axial furrows about one-third the width of the cheeks, and about their own length from posterior margin. Surface of head-shield, including glabella, border, and neck-segment, rather coarsely tuberculated. An indistinct ring of larger tubercles surrounds eyes, and a large tubercle is situated at each end of eyes on inner side. Thorax unknown. Pygidium semicircular, slightly convex, with spinose margin. Axis broad, conical, about one-third the width of pygidium at front end; tapers rather rapidly to obtuse point, nearly touching border; consists of 9–10 segments, of which eight rings are distinct and completely tuberculated across; the 1st, 3rd, 5th, and 7th rings have in addition a large median tubercle. Lateral lobes composed of six (? seven in some) pairs of pleuræ, of which the last pair is very small; each pleura is gently curved, and is divided unequally by a strong longitudinal furrow into a broader, raised, rounded, posterior ridge and a narrower, anterior ridge. The posterior ridge of each pleura crosses a distinct raised, rounded border which surrounds the pygidium and bears a large tubercle at the spot where it crosses and a single median one behind the axis. The posterior pleural ridges are prolonged into short, recurved, equidistant, and subequal spines, projecting freely beyond the margin. (In one specimen there seems to be a median spine behind the axis. In another immature example the anterior two or three pairs of spines are half as long as the whole pygidium.) Surface of pygidium rather coarsely tuberculated; the posterior ridge of each pleura bears 4–5 tubercles, and the anterior ridge 5–6 smaller ones. The axial rings bear each 5–7 tubercles.

DIMENSIONS.

	mm.
Length of head-shield	3·0
Width of head-shield	4·5
Length of pygidium	2·5
Width of pygidium	4·0

REMARKS.—De Koninck[1] published a fuller description of this species than McCoy, but the figures differ in some respects from those given by the latter and from the type-specimens, though the differences are only of minor importance. As stated in the text by De Koninck and indicated in the figure, the lateral lobes of the pygidium possess seven pairs of pleuræ, but the last pair is very small and short; the margin also possesses seven pairs of spines, but no median one behind the axis. In McCoy's figure there are eight pairs of spines and no median one. De Koninck states that the axis of the pygidium consists of 17 segments, but his figure only shows 7, while that of McCoy shows 10. In De Koninck's figure of the head-shield the genal angles are produced backwards and pointed, instead of being nearly rectangular and provided with spines; the glabella, also, is made broad and subtriangular, instead of narrow and subcylindrical as in the types; and the basal furrows or lobes are neither mentioned in the description nor indicated in the figures.

AFFINITIES.—McCoy remarks (op. cit.) that "the greater size of the glabella and its being widest at the base will distinguish the head from that of *Phillipsia* [*Brachymetopus*] *Maccoyi* (Portk.), and the granulation extending entirely across the segments and the spinose margin will distinguish the pygidium from that of *P.* [*Br.*] *discors* (McCoy)." It may, however, be mentioned that the number of segments in the pygidial axis of the latter is much greater, being 17. McCoy also says that *Br. Maccoyi* "is at first sight difficult to distinguish specifically from the Australian species," but the pygidium of the former has 15 segments in the axis, and no spines on the margin, as well as no distinct border with regularly arranged tubercles. In the other British species there are likewise no marginal spines nor border, and all have a greater number of pygidial segments, *Br. ouralicus* having 17 and *Br. hibernicus* 11.

McCoy gave as generic characters the circle of tubercles round the eyes and the pair of large tubercles at the front end of the glabella, but these may well be considered of lower classificatory value, and likewise the relatively greater length of the glabella as compared with European species. It does not, however, seem possible to regard the peculiar pygidial characters in quite the same light, though, as Vogdes[2] says, we have many other genera of

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[1] Foss. Palæoz. Nouv. Galles, 1877, p. 352, pl. xxiv, figs. 10*a*, *b*, *c*.

[2] Vogdes: Trans. Acad. Sc. St. Louis, vol. v (1892), p. 617.

trilobites with spinose and non-spinose representatives. The fewer number of segments in the pygidium and the raised spinigerous border separate it from all the European forms. The genus or subgenus *Phaetonides*, as now understood, is partly distinguished for analogous reasons from the typical *Proetus*; and it seems open to question whether the European species of *Brachymetopus* should not be regarded as constituting a distinct group or subgenus, for which the name *Brachymetopina* may be suggested. Oehlert,[1] in his review of the genus *Brachymetopus* and its allies, does not mention any species with a spinigerous margin to the pygidium; and Claypole[2] was convinced that with the single possible exception of *Phillipsia lodiensis*, Meek, and *Dalmanites* (?) *Cuyahogæ*, Claypole (see below), every Carboniferous trilobite on either side of the Atlantic possessed a pygidium with a definite even outline. Von Möller[3] compared the Australian species *Br. Strzeleckii* with Russian forms, but in his description ascribes to it too many pygidial segments. It is worthy of remark that he figures (op. cit., t. ii, fig. 32) a head-shield (doubtfully attributed to *Br. ouralicus*) which shows the circle of tubercles round the eyes, the pair of large tubercles in front of the glabella, and one median tubercle on the glabella, which are features well marked in *Br. Strzeleckii*.

It is, however, specially interesting to find in the Waverly Group (Carboniferous) of North America members of the genus *Brachymetopus* with spinigerous pygidia like the Australian species. Such are *Br. lodiensis*, Meek,[4] from the Cuyahoga Shales of Ohio, of which Herrick[5] expresses a doubt whether it is a true *Brachymetopus*; *Br. spinosus*, Herrick,[6] and probably *Br. immaturus*, Herrick,[7] and *Br. occidentalis*,[8] Herrick, the three latter of which were referred by Herrick to the genus *Phaetonides*.[9] There is also *Br. armatus*, Vogdes,[10] from the Waverly of Missouri, with a single pair of spines, and *Br. Cuyahogæ*, Claypole, which according to Vogdes (op. cit.) is only an imperfectly preserved example of *Brachymetopus*, and not one of the Phacopidæ.

As McCoy's figures of *Br. Strzeleckii* are not very clear, and Plews'[11] figure is misleading, a restoration, based on the types, is here given of the head-shield and pygidium. (Figs. 1, 2, p. 194.)

The species has been recorded by Etheridge, jun. (Cat. Austr. Foss., Camb. 1878, p. 41), from Dunvegan, Burragood, and Glen William, all in New South Wales.

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[1] Oehlert: Bull. Soc. Et. Scient. Angers, 1885, p. 10 (extract).

[2] Mon. Brit. Carb. Trilob. (Palæont. Soc., 1884), p. 77.

[3] Von Möller: Bull. Soc. Imp. Nat. Moscou, xl (1867), p. 145.

[4] Rep. Geol. Surv. Ohio, vol. ii, Geol. and Palæont., 1875, p. 323, pl. xviii, fig. 3 [*Phillipsia* (*Griffithides*?) *lodiensis*, Meek].

[5] Herrick: Bull. Denison Univ., vol. ii, pt. 1 (1887), p. 57.

[6] Ibid., vol. iv (1889), p. 58, pl. i, figs. 4, 5; and Bull. Geol. Soc. Amer., vol. ii (1891), p. 42, pl. i, fig. 13.

[7] Ibid., vol. iv (1889), p. 59, pl. i, figs. 9–15.

[8] Ibid., p. 57, pl. i, figs. 10*a*, *b*.

[9] Vogdes: Bibliogr. Palæoz. Crust. (Occas. Papers Calif. Acad. Sc.), 1893, p. 284.

[10] Vogdes: Trans. St. Louis Acad. Sc., vol. v (1892), p. 617, pl. xv, figs. 4, 5.

[11] Plews: Trans. N. Engl. Instit. Min. Engin., vol. vi, p. 34, pl. iv.

II.—CREECHBARROW IN PURBECK.—No. 2 (*continued*).

By W. H. Hudleston, M.A., F.R.S., F.G.S.

(PLATE XI.)

(*Concluded from the April Number, p.* 154.)

Varieties of the Creechbarrow Limestone.—There are considerable extremes in this respect, ranging from a soft marly deposit, which soils the fingers like whitening, to a hard compact rock, which takes a good polish. Unquestionably the most dense and compact limestone is that near the summit, whilst the soft marly beds are on the northern slope, and especially near the 500 feet contour, where some of them are earthy and contain a considerable amount of impurity, so that they may at least be called marly limestones. On the other hand, there are compact white limestones, where nests of dog-tooth spar form no inconsiderable portion of the mass. Quartz grains may be noted on most of the weathered surfaces.

The more compact and denser limestones, which prevail near the summit, may be roughly divided into non-pisolitic and pisolitic rocks. Thus, for instance, I have before me (Group 1) specimens of a very heavy and partially calcitic rock. It is a hard whitish limestone without pisolites, but largely interspersed with buff-coloured patches, not unlike some dolomites. Calcitic nests and strings occur, and also strings and stars of black oxide of manganese: the external surface is rough and somewhat honeycombed, and full of curious impressions, some of which may have had an organic origin.

Group 2 comprises those specimens where the pisolitic character is indicated, but not very obviously. A characteristic specimen may be described as follows:—A large fragment of a creamy white tufaceous limestone, with specks and threads of black oxide of manganese in places: flattened pisolitic bodies in brownish calcite are numerous, but not very distinct. There are casts of interiors of a univalve shell, which is most probably *Paludina.* The whole of this fragment has a tufaceous aspect, and is free from buff-coloured patches. The external surface is rough, and in one corner is full of curious shapes, which are doubtless concretionary bodies developed by weathering. On further examination of these curious shapes, I note indications of the concentric structure which convinces me that they are pisolites developed by weathering.

The Pisolites.[1] (Group 3.)—Originally I divided these limestones into four groups, but the pisolitic limestones may be taken as one group. The following is the description of a specimen of this class of rock.

A creamy tufaceous limestone with some buff-coloured patches and with specks and threads of manganese oxide. Sections of ordinary pisolites here and there. But this specimen is remarkable for three very large *horseshoe sections,* which certainly represent concretions in brown calcite. The first specimens I obtained were incomplete in outline, thus causing an appearance of being open at one end, like a horseshoe. Specimens subsequently obtained showed that this was not exactly the case. Where the periphery of the section is complete, as in the specimen figured on Plate XI, Figs. 2 and 3, it is seen that the section of this large concretionary body is thick at one end and thin at the other. Fig. 3 of the Plate especially shows a side view of this curious body, where, taken by itself alone, it might almost be regarded as a fragment of a big belemnite. The section shows a series of concentric rings of brown calcite with a large hollow in the centre filled with the ordinary matrix. There is no radial structure; one end of the circle, as previously noted, is thick, whilst the opposite end thins out to such an extent that in some specimens it is not to be traced. Some of these 'horseshoe' sections are nearly 1½ inches in diameter.

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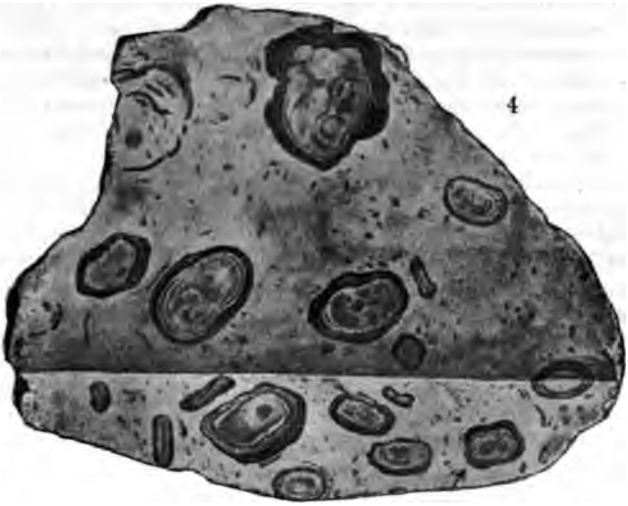
[1] The accompanying Plate is intended to illustrate concretionary or pisolitic action as well as to serve the palæontology of the limestone.

The Egg-like Body. (Plate XI, Fig. 4.)—For a long time these so-called horseshoe concretions were a puzzle to me, and as they were for the most part only obtained in fragments, there seemed to be no possibility of solving the enigma. At last, by good luck we stumbled on a still more curious body, which is perhaps the most perfect pisolite ever discovered. In this case we perceive a pisolitic concretion with an interior like a very small egg, of which the shell, represented by the concentric layers of brown calcite, is developed so obliquely that it is quite thick on one side and thin on the other side. This specimen has been broken so fortunately that we recognize our horseshoe section at once, with the matrix in the form of an egg projecting from the unequally developed circle.

Those who regard pisolites as organic will doubtless welcome this egg-like form as a new species. But, as a further illustration of the eccentricities of concretionary action, I would direct attention to Fig. 1 of Plate XI, where the shell of a univalve, most probably a *Melanopsis*, has been encysted in a number of concentric layers of brown calcite. A similar concretionary action has taken place round other specimens of univalve shells, of which sections are given in Figs. 6 and 8 of the same Plate. This action is interesting from a lithological point of view, but, as we shall perceive subsequently, it renders the palæontology more difficult of interpretation. However, the above instances serve to show that concretionary action has been rampant in the Creechbarrow Limestone, and it is to this action that we must ascribe most of the peculiarities of the rock.

In those cases where the pisolitic concretions are numerous and the limestone is very compact, as shown in Fig. 4, the rock cuts well and takes a fairly good polish. In this instance the ground-mass is of a dull cream colour, mottled with buff patches, and the sections of the pisolites appear in dark brown calcite, which contrasts well with the non-crystallized matrix. There is much more variety in the shapes of the pisolites than can be gathered from the small fragment figured, but they may be classed as quadrate, circular, and oblong, some showing considerable irregularity of outline. Whatever may be the shape of these smaller concretionary bodies, they conform to the conditions already detailed with regard to the larger ones previously described as the horseshoe form. The structure is entirely concentric, and this is shown in the flattened pisolites as well as in the circular ones. Some of these bodies are seen to be compound, with a very irregular periphery, having two or more foci of crystallization, and in this way very curious figures result.



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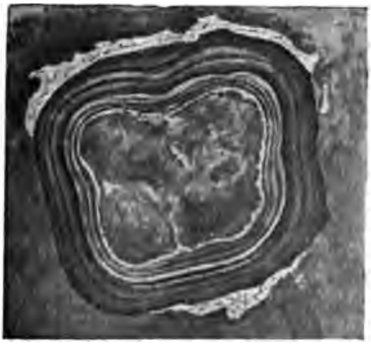

4*a*

Fig. 4.—Fragment of the hard pisolitic limestone showing two faces cut at right angles to each other and polished. 1 × 1½.

Fig. 4*a*.—Section of one of the pisolites, drawn as a transparency. × 6.

The magnified section of one of the quadrate pisolites (Fig. 4*a*) displays some features which are not seen in all the specimens. For instance, there are two lacunæ of clear calcite, which partly separate the regular annular system of brown calcite from the ordinary matrix. This is probably due to partial solution of the matrix subsequent to the formation of the pisolitic concretion We notice belts of clear calcite also in the annular system, especially towards the interior, giving the rings an agate-like appearance. The core, or centre of the pisolite, consists of the matrix partially modified, but without the brown specks which characterize it. This appears to be the case in all sections of the pisolites which I have examined, and suggests that the slight amount of colouring matter, due to iron oxide, which characterizes the rings of brown calcite, has been transferred from the included portion of the matrix to the annular system surrounding it by a sort of centrifugal flow-action, such as that which forms the ironstone shells of limonitic deposits. In the case of some of the pisolites the centre consists of clear crystalline calcite, making the analogy with the ordinary siliceous agate still more complete.

There remains only one further remark to make in dealing with these curious pisolites, and that refers to a suggestion that these concretionary bodies may possibly in the first instance have been due to Nummulites. Everything tends to refute this supposition, more especially the association of these pisolitic limestones with *Paludina* and *Melanopsis*. Yet it must be admitted that there is a considerable resemblance to limestones showing sections of Nummulites, although the resemblance is apparent rather than real, as may be seen on closer investigation, and it can be safely affirmed that nothing approaching organic structure has hitherto been detected in these pisolites. It is certainly a curious coincidence that both *Nummulites lævigatus* and *N. elegans* occur in the Lower Eocenes of this country, mainly perhaps in the Brackleshams, but also in the Barton Beds; so that, if the Creechbarrow Limestone had been of marine origin, there would have been nothing surprising in the occurrence of Nummulites in any beds of Bagshot or of approximate age.[1]

Palæontology.—Very little can be said under this head, as the only specimens of fossils from the Limestone have been derived from the limited area of the summit pit or the immediate neighbourhood. There can be no doubt that *Paludina* is fairly common, as it occurs both in the form of shells and casts by no means infrequently. The shells are often obscured by a concretionary investment, as previously stated, but there is sufficient material to form a fair idea of the species. It is a form which clearly differs from the ordinary Purbeck species (*P. carinifera* and *P. elongata*), but which has a fairly good resemblance to the Bembridge species, *Paludina lenta*, Solander.[2]

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[1] According to Professor Rupert Jones, writing of the physical features of the Bagshot district in 1880 (Proc. Geol. Assoc., vol. vi, p. 437), "the Bagshot sands are the shallow water and western equivalents of the great Nummulitic formation, which is represented in the east by the thick Nummulite limestones, deposited in the open ocean of the period."

[2] In my paper in the GEOLOGICAL MAGAZINE (1902, p. 251), I referred this form to *P. media*, Woodw., a synonym of *P. lenta*, Solander, the latter being the correct name. The history of *P. lenta* is rather a singular one. It was first described by Solander (1766) in Brander's Foss. Hants, and is regarded as ranging from the Woolwich (and Reading) Beds to the Hempstead, Bembridge, and Headon Beds. Hence it is essentially an Eocene and Oligocene species.

No object would be gained by attempting a technical description of fossils so obscured by incrustation as are these Creechbarrow Gasteropoda, but I must direct the attention of the reader to the accompanying Plate XI. According to my ideas, Figs. 1 and 5 represent the back and front view respectively of a form which may possibly be a member of the Melaniadæ. The shell shown in Fig. 1 is enclosed in a series of cysts; the one shown in Fig. 5 appears to me to represent the same species. It is true that the aperture, in its present condition, gives us very little insight into the true character of the shell, but this is due to disfiguration from several causes. Fig. 6 may represent a section of the same species, and here again the elongate character of the whorls points to some member of the Melaniadæ rather than to *Paludina.*

In the case of Fig. 9 the aperture has been better preserved, and few would doubt that this specimen represents a *Paludina.* It most resembles *P. concinna,* Sowerby, which Mr. Bullen Newton ("British Oligocene and Eocene Mollusca") regards as the same as *P. lenta.* Although there are plenty of casts in the limestone which one would refer without hesitation to *Paludina,* this is the only specimen of a shell which shows the *Paludina* mouth with certainty.

Figs. 7 and 8 of the Plate represent specimens (the latter in section) which have suffered terribly from incrustation, to the complete obliteration of the true external form; yet I think that in them we may recognize *Melanopsis brevis,* Sowerby, described from the Bembridge series. I have no doubt that a more extended search would yield a larger series of fossils, since the few specimens of Gasteropoda which have been figured were derived from a very limited area, viz. the summit pit.

As regards any other fossils from the Creechbarrow Beds, there is a fragment something like *Ditrupa* in one of the more earthy limestones. A bivalve not unlike a *Lucina* was also obtained from a fragment of an ironstone grit found on the surface between the summit and the eastern spur, but, as I have never seen this particular bed *in sitû,* too much importance should not be attached to this 'find.'

Conclusion.—The question of the actual age of the Creechbarrow Limestone is one which I have naturally deferred to the last, in order that we might be in possession of all the available evidence. Its approximate age is clear enough as being Lower Tertiary, but the question now more particularly to be solved is this—Are we to believe that the Creechbarrow Limestone is really of Lower Bagshot age and rather low down in the Bagshot series, as appearances might seem to indicate, or are we to believe that it is of Oligocene age and a local representative of the Bembridge Limestone? It has already been admitted that hitherto I have failed to settle this question from a study of the stratigraphy of the hill, although the bulging of the Pipeclay series is certainly in favour of the view that the Creechbarrow Beds do not overlie the Pipeclay series, as must be the case if they or any portion of them represent the Bembridge Limestone.

Do we obtain a better clue either from the lithology or the palæontology of the limestone? I fear not. The two species of Gasteropoda, which may be regarded as fairly well identified, viz. *Paludina lenta* and *Melanopsis brevis*, are certainly Bembridge species, but the former occurs in the Woolwich Beds, and we may well believe that the latter also had a long life as a Lower Tertiary fresh-water species, so that its presence must not be taken as indicative of any special horizon. The lithology is equally uncertain.

So far as I am acquainted with museum specimens of the Bembridge Limestone, it has a somewhat different aspect to that from near the summit of Creechbarrow, and is, on the whole, non-pisolitic. Yet there are in the Bembridge Limestone some very enigmatical bodies. Amongst these are the supposed 'Cocoons' referred to by the late Mr. F. E. Edwards as possibly being the eggs of fresh-water tortoises, or even snails. These bodies are said to possess no internal structure. Not having any of these 'Cocoons' by me at the present moment, I am unable to give any further description of them, although I strongly suspect that they are not organic any more than our 'horseshoe' pisolites, but most probably the result of concretionary action. Hence there would seem to be established a certain degree of analogy, *quâ* lithology, between the Bembridge and Creechbarrow Limestones, although this can scarcely be allowed to outweigh the stratigraphical inferences to be drawn from the bulging of the Pipeclay series.

Thus, on summing up all the evidence hitherto available, I rather incline to the view that the Creechbarrow Limestone and associated beds are of Lower Bagshot age, yet at the same time I am bound to admit that it is a point which can only be decided with certainty by further investigation.

Postscript.—Since the article on Creechbarrow was completed there are two points on which a certain amount of additional information has been received.

(1) A deep boring south of Mr. Bond's brickyard is thought by Mr. Leonard Pike to indicate the presence of Pipeclay at a considerable depth within the area hitherto regarded as sterile. If the clays in this boring represent the great mass of Pipeclay such as has been excavated from the 'Old Clay Pits,' then the theory that Creechbarrow bulges the Pipeclay series can scarcely be maintained any longer. But if, on the other hand, the material lately discovered is merely a local manifestation of Pipeclay such as might occur to a small extent on almost any Bagshot horizon, the recent discovery cannot be regarded as contravening the general impression which has hitherto prevailed.

(2) On referring to Edwards' monograph of the Eocene Mollusca (Pal. Soc., 1852), I perceive that he describes with considerable detail the bodies regarded as the casts of eggs which were found in the Bembridge Limestone. Those most commonly found, he says, present a close resemblance both in size and shape to the eggs of several of the fresh-water tortoises, and may be casts of the eggs of

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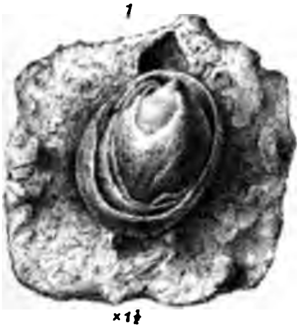

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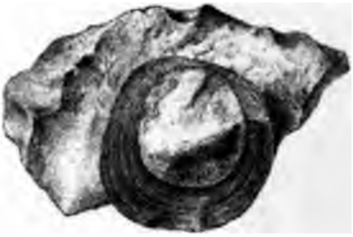

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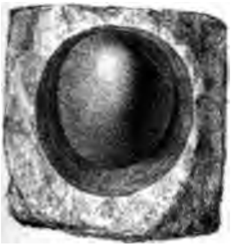

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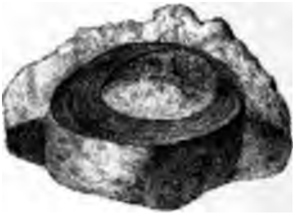

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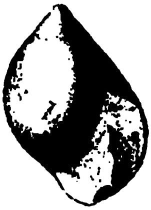

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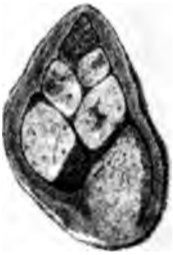

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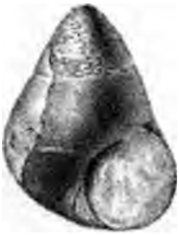

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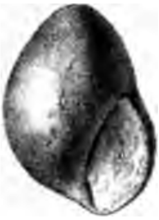

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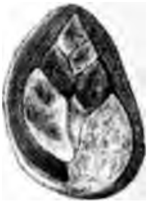

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G. West lith.

SHELLS & CONCRETIONS FROM
THE CREECHBARROW LIMESTONE.

species of *Trionyx* or *Emys*, which lived in the Eocene marshes. Others he thought might be casts of some Helicidæ.

Although we cannot show anything from the Creechbarrow Limestone which exactly corresponds to the supposed eggs from the Bembridge Limestone, yet a successful reconstruction of the larger 'horseshoe' pisolites from Creechbarrow might possibly produce forms not unlike the 'eggs' which attracted the attention of Mr. Edwards. If this should prove to be the case, there may be more similarity between the two limestones than has hitherto been supposed.

EXPLANATION OF PLATE XI.

Fig. 1.—Gasteropod encysted in concretionary layers; ? one of the Melaniadæ. × 1½.
,, 2.—Section, approximately horizontal, of the 'horseshoe' concretion. Nat. size.
,, 3.—Section of the 'horseshoe' concretion, drawn so as to show a portion of the outer wall. Nat. size.
,, 4.—Egg-like body inside the 'horseshoe' concretion. × 3.
,, 5.—Gasteropod; ? one of the Melaniadæ. Front aspect. × 1½.
,, 6.—Vertical section of Gasteropod, probably the same species as shown in Figs. 1 and 5. × 1½.
,, 7.—Cf. *Melanopsis brevis*, Sowerby. Front aspect. × 1½.
,, 8.—Section of a similar specimen. × 1½.
,, 9.—*Paludina* cf. *lenta*, Solander. Front aspect. × 1½.

N.B.—Figs. 6 and 8 show the encrusting action to which most of these shells have been subjected, and which tends to obscure their true character.

III.—The Lower Pliocene Bone-bed of Concud, Province of Teruel, Spain.

By Arthur Smith Woodward, LL.D., F.R.S., of the British Museum.

(PLATE XII.)

FROM time immemorial a remarkable accumulation of bones in the province of Teruel, Spain, has attracted attention. It is especially conspicuous in the low range of hills near Concud, and the people of that village seem to have generally regarded it as marking an ancient battlefield. So long ago as 1754 Torrubia briefly described this deposit in his Spanish Natural History;[1] but his curiosity seems to have been aroused not so much by the bones themselves as by the crystalline calcite found occupying many of their cavities. Twenty years later an Englishman, William Bowles, again referred[2] to the same bone-bed, and described it as containing the remains of men and women mingled with the bones of horses, donkeys, oxen, and smaller domestic animals. He also observed that the limestone above the bone-bed was filled with land and fresh-water shells. Cuvier quoted Bowles' description in his treatise on fossil bones,[3] and after an examination of some teeth and bone-fragments collected by Proust at Concud, he was inclined to believe that these fossils really represented domestic animals as already determined, though he found no associated evidence of man. He suspected that Bowles was wrong in describing the bone-bed as a regular stratum, and thought it would probably prove to be a breccia introduced into a fissure in comparatively modern times.

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[1] J. Torrubia: "Aparato para la Historia Natural Española" (1754); German edition (1773), p. 63.

[2] Guill. Bowles: "Introduccion a la Historia Natural y a la Geografía Física de España" (1775), p. 210.

[3] G. Cuvier: "Recherches sur les Ossemens Fossiles," 4th ed. (1835), vol. vi, p. 427.

The true nature and age of the deposit at Concud were first determined by the researches of De Verneuil, Collomb, and De Lorière,[1] who not only made geological observations but also collected fossils and submitted them to Paul Gervais. In 1853 Gervais perceived that the supposed teeth of horses and donkeys belonged to the extinct *Hipparion*;[2] and it became evident that the basin of Teruel was occupied by an Upper Tertiary lake deposit, closely resembling other lacustrine formations which were then being recognised in various parts both of Spain and France. Ten years later the province of Teruel was systematically surveyed by Vilanova, who published a pioneer geological map and description;[3] while in 1885 the province was the subject of a final memoir by Cortázar, issued by the present Geological Survey of Spain.[4] All these researches gradually confirmed the impression that the Concud bone-bed contained the remains of the same Lower Pliocene mammalian fauna as the well-known deposits of Mt. Léberon, in France, and Pikermi, in Greece.[5]

The remote and elevated plain on which Teruel is situated was made readily accessible last year by the opening of the Aragon Railway from Sagunto to Calatayud. Being interested in the Pikermi fauna, I therefore decided in the Autumn to spend a brief holiday at Concud and make a preliminary inspection of the ground. Thanks to the kind intervention of A. Frederick Ivens, Esq., British Vice-Consul in Valencia, and E. Harker, Esq., British Vice-Consul in Castellon, I obtained introductions to Señor Don Gregorio Lleo, Chief of the Forest Department in Teruel, to the Provincial Governor, and to the Alcalde of Concud. The friendly reception and help accorded to me by these officers and by the village council of Concud enabled me to attain my object; and among the villagers themselves I found both willing guides and workmen. I am also much indebted to Mr. Thomas Rees, of the Grao de Valencia, who accompanied myself and my wife, and contributed to our success by his intimate knowledge of the Spaniards and their customs.

Concud is about three miles distant from Teruel in a northerly direction, and the low hills in which the bone-bed is exposed are nearly two miles further away. These hills are at an elevation of

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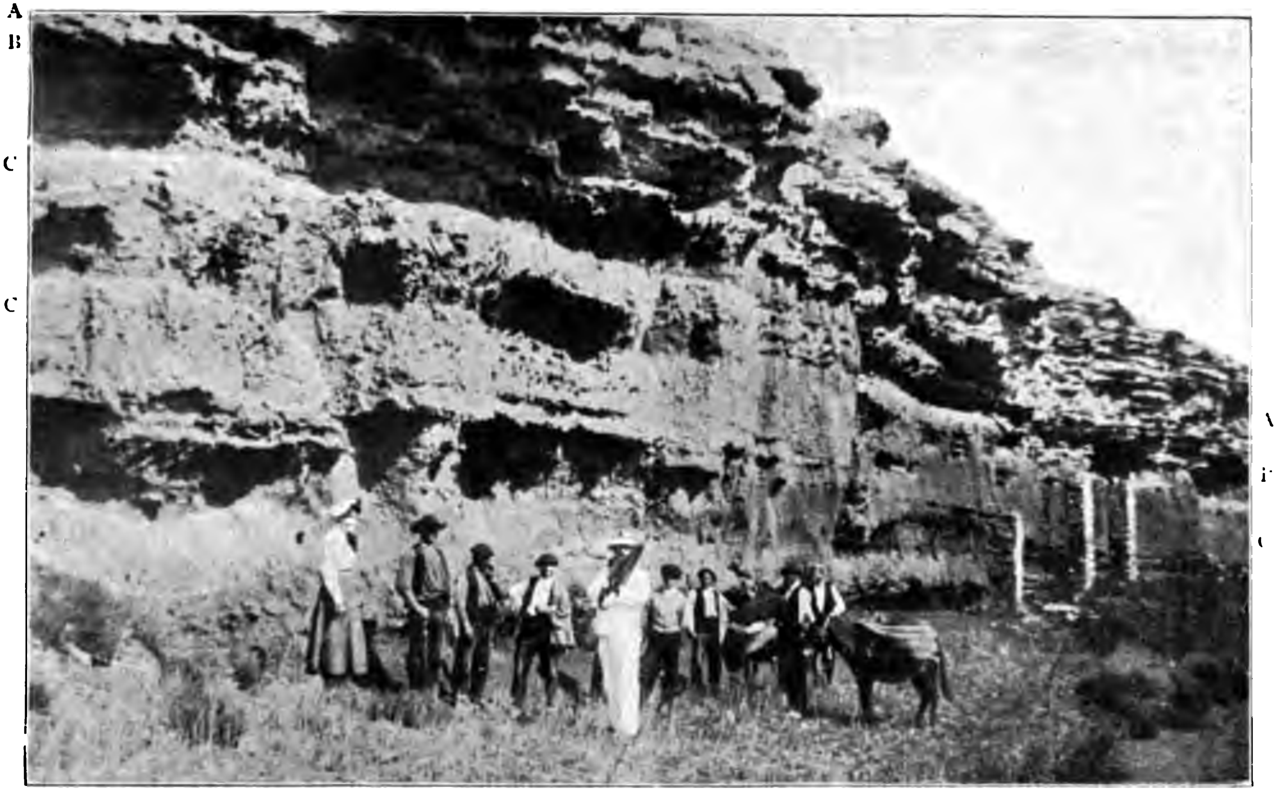
[1] E. P. de Verneuil & E. Collomb, "Coup d'Œil sur la Constitution Géologique de quelques Provinces de l'Espagne": Bull. Soc. Géol. France [2], vol. x (1853), p. 74.—P. Gervais, "Description des Ossements Fossiles de Mammifères rapportés d'Espagne par MM. de Verneuil, Collomb, et de Lorière": ibid., pp. 147–167, pls. iv–vi.

[2] P. Gervais: loc. cit., p. 155, pl. iv, fig. 4.

[3] J. Vilanova y Piera: "Ensayo de Descripcion Geognóstica de la Provincia de Teruel": Junta General de Estadistica, 1863.

[4] D. de Cortázar, "Bosquejo Físico-Geológico y Minero de la Provincia de Teruel": Bol. Com. Mapa Geol. de España, vol. xii (1885), pp. 263–607, with map and sections.

[5] A. Gaudry: "Animaux Fossiles et Géologie de l'Attique," 1862.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about 3,000 feet above the level of the sea, and capped with irregular thin beds of limestone. They are so barren as to be scarcely of use even for the pasturage of sheep, of which poor flocks are kept. At the time of our visit the red-legged partridge was in season and very abundant.

For a distance of about four miles along the outcrop we continually found traces of bones and teeth in the talus from the softer beds immediately beneath the limestones; but the bone-bed itself was best exposed in the vertical walls of the classical ravine—the Barranca de las Calaveras, or Valley of Skulls—originally described by Torrubia and Bowles. We eventually halted here and spent a few days in extricating the fossils.

The northern wall at the entrance of this small ravine is shown in the photograph reproduced in Plate XII. At the top (A) are observed the overhanging ledges of limestone. Beneath these is a layer of comparatively soft marl and sand (B) which is filled at most spots with bones. The lower half of the section then consists of hard red marl and sandy layers (C), with occasional beds of well-rounded pebbles, which form prominent ridges on the weathered face. At this point the bone-bed is inconveniently situated for satisfactory excavation. We therefore followed it to the head of the ravine, where the floor rises to its level and makes it comparatively accessible.

At the point where our chief excavation was made, the overhanging beds of limestone are from 4 to 6 metres in thickness. They form irregular layers, some consisting chiefly of the fresh-water shells described by Vilanova, others composed entirely of chemically precipitated travertine. The shelly layers contain an occasional bone or tooth, but no accumulation of mammalian remains. At the base of the limestone there are traces of lignite and bituminous marl, also enclosing a few scattered bones and teeth. Next below is a bed of white marl, about one metre in thickness, almost unfossiliferous but with occasional traces of lignite. Then follows a greenish-yellow, soft, sandy bed, about 30 centimetres thick, with an admixture of white and greenish marl, sometimes bituminous at the base. This is the true bone-bed, and immediately below it occurs the unfossiliferous series of brick-red sandy marls and conglomerates so well shown in Plate XII (C).

The bones in the bone-bed do not form an absolutely continuous mass, but occur rather in dense patches. They vary in state of preservation, and at the spot where we worked they were made fragile by moisture and much distorted by crushing. The specimens we obtained, indeed, suggest that they had become more or less rotten even before burial; and I observed no satisfactory evidence of naturally associated bones—either pieces of limbs or of vertebral column—such as are common in the bone-beds of Pikermi. The teeth alone proved to be well preserved, and complete jaws were often met with. There were no associated pebbles.

The large majority of the remains in the Concud bone-bed belong to *Hipparion gracilis*. The teeth of this species are especially common everywhere. There is also evidence of a larger variety of *Hipparion*, which may perhaps belong to a second species. We found one mandible and one upper jaw of *Rhinoceros*, with teeth closely resembling those of *R. Schleiermacheri*, but not quite identical. Some decayed fragments of limb-bones and a small piece of a tooth, not worth preservation, clearly represented *Mastodon*. A mandibular ramus, various teeth, and horn-cores are identifiable with *Gazella brevicornis*. Other teeth represent an undetermined larger antelope. Vilanova has also recorded doubtful traces of *Cervus* and *Hyæna eximia*,[1] while Cortázar mentions the discovery of teeth of *Sus*.[2]

A deposit which yields remains of so interesting a mammalian fauna to the casual work of a few days with a small party of men, deserves further systematic exploration. It is true that in all the spots we examined near Concud excavations are rendered difficult by the mass of overlying limestones, which, in the absence of timber, need to be supported by pillars of masonry when the marl and bone-bed are removed. Similar bones, however, have been noticed in many other parts of the Teruel basin, and it is quite likely that extended search would lead to the discovery of better preserved and more readily accessible material.

Such renewed and extended exploration would also be of much interest from a purely geological point of view, considering the result of recent researches in some of the so-called Tertiary lake basins of western North America, and in the remarkable Tarija Valley in Bolivia. According to Matthew[3] and Hatcher,[4] the North American deposits in question, with their wonderful bone-beds, cannot have been formed in great sheets of water, but are partly wind-borne, partly fluviatile, partly formed in temporary pools. According to Nordenskjöld,[5] the Tarija Valley was once a steppe, and the remains of *Mastodon* and other quadrupeds now found buried there represent animals which lived on the spot and were engulphed in shifting pools and mud-flats. Hatcher, indeed, considers that similar deposits are now accumulating on some of the flood-plains in the higher reaches of the great rivers of South America. Quoting a recent observer, Mr. H. H. Smith, he alludes to a plain about 400 miles long and in some places 150 miles wide, which is periodically flooded by the River Paraguay. "Even at low water at least one-fourth of it is flooded: when the river is at its highest the whole plain is a vast lake covered with floating grass and weeds; it is possible to pass almost straight across it in a canoe, though with great difficulty. Only a few islands remain here and there; jaguars, deer, and other animals take refuge on them."

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[1] Named *Hyænictis græca?* by Vilanova, redetermined by Gaudry, "Les Ancêtres de nos Animaux," 1888, p. 202.

[2] D. de Cortázar: loc. cit., p. 449.

[3] W. D. Matthew, "Is the White River Tertiary an Eolian Formation?": Amer. Nat., vol. xxxiii (1899), pp. 403–408.

[4] J. B. Hatcher, "Origin of the Oligocene and Miocene Deposits of the Great Plains": Proc. Amer. Phil. Soc., vol. xli (1902), pp. 113–131.

[5] E. Nordenskjöld, "Ueber die Säugethier-fossilien im Tarijathal, Südamerika": Bull. Geol. Inst. Upsala, vol. v (1901), pp. 261–266.

Under these circumstances some at least of the skeletons of drowned animals would be buried in the sediment at the bottom of the flood; while any accumulation of bones lying on the plain would be rapidly entombed. That great accumulations of this kind often do occur near water, is indicated by Mr. Hesketh Prichard's observations recorded in his recent book on Patagonia.[1] On the bank of one small muddy lake he found a heap of at least 500 skeletons of guanaco, which had perished during the severities of the previous winter. "Their long necks were outstretched, the rime of weather upon their decaying hides, and their bone-joints glistening through the wounds made by the beaks of carrion-birds." A desolate plain adjoining Lake Viedma is also described as covered with the bones of guanaco and other mammals in great profusion. In fact, in winter the animals seem to congregate near drinking-places where the water is likely to be free from ice, and there they die of starvation in immense numbers.

According to an observation communicated to me by Professor McKenny Hughes, when bones are exposed to the vicissitudes of ordinary weathering they often disintegrate into sharp flakes. He has noticed this phenomenon especially in the case of bones of rabbits scattered on the ground. It is therefore quite likely that the sharp splinters found mingled with the complete bones in many of the bone-beds are not the result of any physical violence, but merely of prolonged exposure to the elements.

IV.—The Diffusion of Granite into Crystalline Schists.

By Edward Greenly, F.G.S.

(PLATE XIII.)

1. *Roberts-Austen's Experiments on the Diffusion of Metals.*

ABOUT a year ago my friend Professor Dobbie, of the University College of North Wales, drew my attention to the remarkable experiments of Sir W. Roberts-Austen (whose premature death we must lament as a very great loss to science) on the diffusion of solid metals, suggesting that they might have some geological application. The phenomena referred to in this paper, in which I have been very keenly interested ever since my work as a Geological Surveyor in Eastern Sutherland, occurred to my mind at the time as a probable case; but after some reflection certain difficulties began to appear, and I put the subject aside for a while. The very suggestive address of General McMahon to the Geological Section of the British Association at Belfast has reawakened my interest; and it seems to me worth while to put forward some considerations on the matter, somewhat speculative indeed, but which may perhaps be of service in stimulating research on a fascinating though difficult subject.

Sir W. Roberts-Austen[2] showed that certain selected substances, especially gold and lead, were able to diffuse into each other in the solid state, and at temperatures far below the fusion-point of either.

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[1] H. H. Prichard: "Through the Heart of Patagonia" (1902), pp. 189, 203, 254.

[2] Roberts-Austen: Bakerian Lecture, Phil. Trans., 1896, vol. clxxxvii; Proc. Roy. Soc., Oct. 1900, p. 436.

Rods of the metals were placed end to end, and in each case the gold diffused upwards into the lead.

At the end of four years, at only 18° C. (ordinary Summer temperature), gold could be detected 9·95 mm. from the contact. At 251° C., which is still 75° C. below the fusion-point of lead, at the end of 31 days, ·002 per cent. of gold was found 7 cm. from the contact. If the column of lead was kept liquid, the diffusion was much faster. But as much gold would pass up into liquid lead in a day as into solid lead at 18° C. in 1000 years.

It is clear, therefore, that in solids, as General McMahon remarks, as well as in liquids and gases, there is a good deal of molecular movement; and as we cannot suppose this to be confined to a few cases only, we may expect diffusion to take place between many solids under favourable conditions. Any pair of solids cannot, of course, be expected to diffuse, any more than any pair of liquids—mercury and water, for example. But solids with as much in common as most silicate-bearing rocks might reasonably be expected to do so.

2. *The Metamorphic Theory of Igneous Rocks.*

Before attempting to apply Roberts-Austen's results, it will be desirable to refer to the relation of granites to crystalline schists in highly metamorphic regions; and, first of all, to review a theory which at one time had much influence upon geological opinion, and even now continues to recur from time to time to the mind of the worker in regions of this description.

The eruptive nature of granite has, ever since the classic demonstration of Hutton, been rightly regarded as one of the established truths of geology, and this has been confirmed by numberless examples since discovered in all parts of the world, and in rocks of all ages.

But the phenomena to be seen at the margins of granites do not always show clear evidence of intrusion, and the study of some of these led to a modification, about the middle of the nineteenth century, of Hutton's original view. That granites are often, perhaps generally, intrusive, was never, I believe, denied. But it was asserted that in many cases the margins showed a gradual transition into the material of the surrounding rocks; and it was inferred that these rocks had been in such cases, not merely altered in mineral character, but actually melted down, and had recrystallized in cooling as granitoid material; that, in fact, the granite was, in part at any rate, of metamorphic origin. From this view it was an easy transition to that according to which such granites were regarded as of metamorphic origin throughout their whole body; the heat to which such fusion was due being then ascribed, not to intrusion of heated foreign matter, but to local intensification of the internal heat of the earth. A comprehensive resumé of the theory is given, with his usual admirable lucidity, by the late Professor A. H. Green in his "Physical Geology" (ed. 1882, pp. 399–455).

Unfortunately, however, the theory was not always applied in this moderate and scientific spirit. The chemical composition of even the acid igneous rocks always presented difficulties, but basic rocks and, I believe, even peridotites and serpentines were sometimes supposed to have originated in this way, as well as felsites, which could not have consolidated under plutonic conditions.

It is easy to be wise after the event, and for one period of human thought to point the finger of scorn at the aberrations of its predecessors; and we must not forget that at that time hardly anything was known of the microscopic structure of rocks, and very little more of their chemical composition.[1] When, therefore, in the light of microscopic and chemical research the field evidence for many of the alleged cases of transition broke down, it is not surprising that the whole theory was cast aside, often with no little scorn, and relegated to the limbo of exploded hypotheses.

The remark has been made by Mr. Herbert Spencer that as there is "a soul of goodness in things evil," so often is there, and that very generally, "a soul of truth in things erroneous." And in this old theory there *was* a soul of truth.

It is noteworthy that most of the cases in which the evidence so hopelessly broke down were those where the igneous rocks were surrounded by tracts of ordinary sedimentary rocks that were only locally, not regionally, metamorphosed. Regionally metamorphosed rocks had been, indeed, examined, and speculation aroused concerning them; but the time for systematic research into their phenomena had not yet come.

The past twenty years or so, however, have seen much energetic and enthusiastic research into the crystalline schists, and really scientific methods applied to their problems. Now, during that period descriptions have been given, from time to time, of a good many cases where granitoid rocks which occur in districts of regional metamorphism have been really observed to pass into the surrounding gneissose rocks by perfectly gradual transitions. North America, Scandinavia, Saxony, the Alps, more than one part of the Scottish Highlands, Ireland, and even Anglesey, have furnished examples.[2]

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[1] The time and labour demanded by analyses of silicates have always stood in the way of a really thorough knowledge of the chemistry of rocks, and at the present time hardly any work is so much needed in geology, if intelligently directed in conjunction with microscopic and especially with field work.

[2] Lawson: Geol. Rainy Lake Region, 1888, pp. 118, 130, 137.
Van Hise: Pre-Camb. Rocks N. America, Corr. Papers, 1892, p. 488; and, quoting Jukes, Hitchcock, and others, p. 479.
Reusch: The Bömmel and Karm Islands, 1888.
Lehmann: Enst. Altkryst. Sch., pp. 64, 67, etc.
Lory: Etudes Sch. Cryst.: Congrès Inter. Geol., 1888.
Bonney: Pres. Address Geol. Soc., 1886, p. 51, etc.; Two Traverses Cryst. Sch. Alps, Q.J.G.S., 1889, pp. 95, etc.
Barrow: An Intrusion Muscovite-Biotite Gneiss, etc.: Q.J.G.S., 1893, pp. 341, 343, 353.
Horne & Greenly: Fol. Granites and Cryst. Sch. East Sutherland: Q.J.G.S., 1896.
Cole: Metam. Rocks Tyrone and Donegal: Roy. Irish Ac., xxxi (1900).
Greenly: Sillim. Gneiss, Anglesey: GEOL. MAG., 1896, p. 495.
Teall: Pres. Address Geol. Soc., 1902, p. lxxiv.
(These references are of course not exhaustive.)

3. *Gneisses and Granites of Eastern Sutherland.*

The phenomena of Eastern Sutherland were described some years ago in a joint paper by Dr. John Horne and myself.[1] The granites, which are generally foliated, lie as sills in a region entirely composed of gneissose rocks in which no original structures whatever have been detected. On parts of the northern coastline, where granulitic, somewhat siliceous rocks prevail, the granitoid matter is injected "lit par lit," producing complex synthetic banded gneisses. But on other parts of the coast, and inland about Kinbrace, where a flaky or wavy biotite gneiss is the dominant type, we find the permeation phenomena.

In "lit par lit" injection the injecting and the injected rock retain their separate individualities, however thin and frequent may be the sills; whereas at the permeation junctions "the margins of a sill fade off into the gneiss through a series of thinner and thinner lenticles" (Pl. XIII, Fig. 1), "the ends of a sill also fading off into the gneiss by a dovetailing of biotitic folia into the granite" (Pl. XIII, Fig. 2). "Finally, large masses occur in which these relations are carried to such a degree of intimacy as to render it very difficult to decide whether to regard them as granite or as gneiss (Pl. XIII, Fig. 3), difficult even to produce a consistent map, all lines being wholly arbitrary" (op. cit., p. 644).[2]

In the same paper (pp. 642–3) evidence is adduced to show that much of the gneissose rock so permeated must be of sedimentary origin. That it does not consist merely of the material of the adjacent granites altered by marginal shearing is shown by the existence of uninjured intrusive junctions at other parts of the same sill (ibid., figs. 2, 3). In conclusion (ibid., pp. 647–8) it was suggested, though with the caution due to the chemical difficulties to be encountered, that the granites might not be wholly foreign matter; and this was alluded to in the discussion by several speakers, who pointed out that the suggestion was really a revival of the older theory which I have described above.

4. *Application of Roberts-Austen's Results.*

Now, in the interpretation of phenomena of this kind the results of Sir W. Roberts-Austen's experiments seem to open up a prospect of considerable help. In the permeation zones of these granites, whatever may be their cause, we see, at any rate, an unquestionable case of the diffusion of one rock into another.

Roberts-Austen has shown (1) that diffusion takes place between closely adpressed solids at ordinary temperature, (2) that with rise

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[1] "On Foliated Granites and their relations to the Crystalline Schists in Eastern Sutherland": Q.J.G.S., 1896. The views of our colleague, the late Hugh Miller, jun., are also given in this paper.

[2] I had not at the time this was written read this passage from Lehmann (Enst. Altkryst. Sch., p. 64): "Die Abgrenzung zwischen dem, was als Granit oder Granitgneiss und dem, was als Gneissglimmerschiefer zu bezeichnen wäre, wird oft unmöglich *und kommt ganz auf subjectives Ermessen hinaus*, so schnell wechselt der Gesammtcharakter," but cannot refrain from quoting it now. I put one phrase in italics.

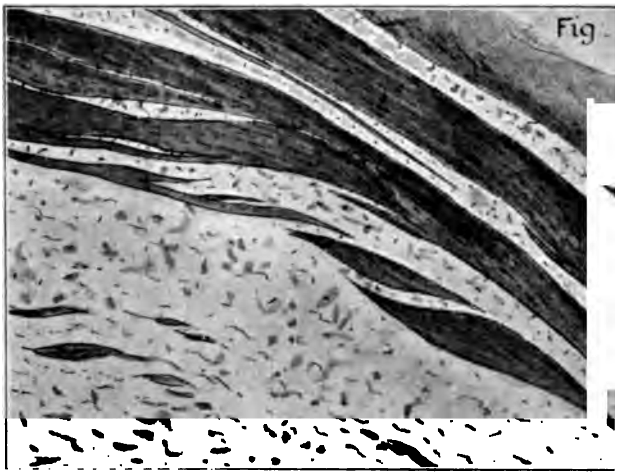

Fig. 1.—Side of Granite Sill, Strathy Point.

Note.—The junctions here shown are much sharper than those of the true perme
the softness of which it is very difficult to represent.

Fig. 2.—End of Granite Sill, Kinbrace.

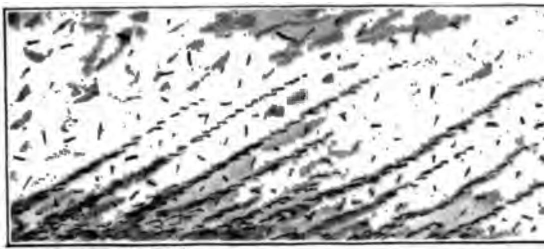

Fig 2.

Fig3.

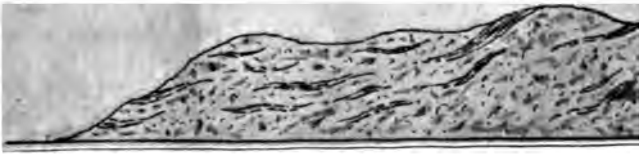

Fig. 3.—Cliff about 200 feet high. Glas Eilean, Strathy Po

nperature diffusion is greatly accelerated, (3) that if the rature is kept permanently above the fusion-point of one of bstances, diffusion is still further accelerated.

nay be asked why there is any necessity to appeal to these ı, seeing that we have long known that igneous magmas are ed in a liquid state, and into remarkably narrow veins. But inary igneous intrusion can account for all the phenomena consideration, why do we not find permeation zones surrounding trusive rocks, even ordinary basalt dykes, for there is reason ieve that basic magmas have a high degree of liquidity?

the other hand, it is clear that solid diffusion does not take between rocks by mere close adpression, even after long periods e, for junctions of normal igneous, even plutonic masses with ɔntary rocks of all ages, as well as junctions of igneous and ɔntary rocks with one another, can be seen at which no ation whatever has taken place. Rocks do not, it is evident, ı with the ease that gold and lead do.

s clear that another factor must be necessary, and this can be I believe, in the existence of *an already high temperature in the nding rocks.*

inary igneous intrusions, as is shown by their chilled edges, the rocks into which they were injected relatively cold, i.e., not ɔiably above the temperature proper to a zone of the earth-far outside that from which the magma came. They cooled, ore, at the margin soon after injection, and did not remain in ıt at a high temperature for any length of time.

there is abundant evidence in permeation regions that the e at the time of injection found the surrounding rocks already ıigh temperature. The junctions in Eastern Sutherland are ɣ exposed in a great many places; and yet no sign of a chilled n has been detected anywhere. The same is the case in other ıs. (Indeed, "lit par lit" injection itself would appear, *ri*, to be possible only among hot rocks, as seams so thin would ɔnsolidate among cold rocks, and so fail to make their way for istance.)

now, we suppose a granitic magma introduced among rocks with existing temperature scarcely lower than its own (it might be higher if the rocks were less fusible), not only would much intimate intrusion be possible, but even when actual intrusion l the granite sills and the adjacent rocks would retain a high rature at the junction for a very long time. The conditions, t, would be related to those of ordinary intrusion somewhat as of a column of liquid lead poured into a hot cylinder on to hot vould be to those of lead poured into a cold cylinder on to cold Solidification would be long delayed, and all this time the a might reasonably be expected to diffuse into the surrounding following their natural divisional planes, and giving rise to ı phenomena of a permeation zone.

ı singular fact that the inclusions of gneiss in granite, even down thinnest films, are so very seldom, in these zones, disturbed in position (ibid., fig. 4), affords some support for the view that the extension of the magma proceeded by quiet diffusion rather than by forcible injection.

An explanation would also be found for the occurrence of lenticles of granite in complete isolation from the parent mass.

The experiments quoted lead us to expect that diffusion might go on even after solidification, seeing that in such a complex a high temperature would be maintained for a long time, thus extending the permeation zone yet further, and in perhaps an even subtler manner. Indeed, what we know of the changes that have certainly gone on in solid rocks shows that the solid state is no obstacle to extensive molecular change.[1]

The principal difficulty would be this. The solids of the experiments were homogeneous, being pure metals, so that diffusion took place between molecules of only one kind on either side. Whether the liquid magma of a granite was a completely homogeneous liquid we do not know, but certainly after solidification no granite is a homogeneous solid. Molecules of at least three kinds would therefore, it would appear, have to diffuse in order to convey granitoid matter from place to place, and that in due proportion. This is certainly a difficulty, though not an impossibility.

Moreover, are we quite sure that solid diffusion would be obliged to proceed in this way? At the close of the paper by Mr. Horne and myself to which reference has been made, it was pointed out (ibid., pp. 647–8) how little is known of the chemistry of the compounds of silicon, and how very much may be hoped for from an extension of that knowledge, when we consider the chemical analogies presented by that element and the part which it plays in Nature.[2]

V.—Vein-Quartz and Sands.

By A. R. Hunt, M.A., F.G.S.

SOME time ago my friend Mr. Jukes-Browne asked me to examine some sand, with a view to ascertaining whether it was derived from Dartmoor. Dartmoor quartzes have so many specific characters that it is often easy to say that a quartz is not derived from that region; but owing to the fact that quartz-veins have not been studied, it is usually impossible to say whence various sands have in fact come.

In the course of conversation, Mr. Jukes-Browne suggested my submitting a short letter to the Geological Magazine, as the subject might interest students; but the more I looked at the matter the more abstruse and cumbrous did it appear; and, from past experience, I doubted whether the inquiry would not be more attractive to chemists than to geologists.[3]

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[1] Hitherto we have been under the necessity of invoking the agency of percolating water.

[2] My friend Dr. Horne very kindly read the MS. of this paper, and he gives me leave to say that he agrees with the views expressed in it. Indeed, I believe it would be nearer the truth to say that he had come to similar conclusions *before* he saw my MS., and had discussed them with my former colleagues of the Scottish Geological Survey.

[3] I was unaware at the time that quartz-veins were under discussion in the Magazine.

In December, 1886, when examining marine sands, I pulverized a flint pebble and several quartz-pebbles for the sake of comparison in the microscope. I noted that the first quartz-pebble I examined was full of enclosures with bubbles. Subsequently I had more than a dozen vein-quartzes sliced. Not only did they all contain bubbles, but they all contained moving bubbles, the infallible proof of the presence of fluid. Quartz-veins and granites are near of kin, and in 1889 I wrote a paper on granite. My interest in sands and granites led me to appeal more than once to the most distinguished honorary member of our local Society, Dr. H. C. Sorby, F.R.S., who was most unsparing in his assistance in both of those subjects, which he had so long made his own. However, as might be expected, the nut proved too hard for me to crack. But Dr. Sorby's old correspondence has now put me into no slight dilemma. I cannot publish it, and I can scarcely absorb the ideas and dispense them as my own; while the last thing I should care to do would be to appear in the slightest degree to sit in judgment on the master. Yet the only points which interest me are those in which I do not quite understand Dr. Sorby; the fault being no doubt my own, if only for not having sought an explanation direct.

One point which has caused me much thought in the matter of sands is the omission by Dr. Sorby of all mention of quartz-veins as one derivation of quartz-sands, both in the addresses to the Microscopical and Geological Societies. The same doubt arises in the case of M. Delesse and the beaches of the French coast. We hear much of hyaline quartz-sand, but nothing of vein-quartzes; yet vein-quartz seems an important constituent of grits and sandstones. There are, moreover, many quartz-veins the sands derived from which could not be distinguished from sands derived from granites, seeing that water inclusions, carbonic acid inclusions, chlorides, and negative crystals are found in both varieties. We need not flatter ourselves that we can distinguish a granite quartz by its clearness and freedom from opacity. Rock crystal is the clearest of quartz, and it is no rare thing to find water-clear crystals and milky crystals lying side by side in the same drusy cavity; while between the two there may be found elsewhere every gradation. When once we begin to reflect on the whys and the wherefores of quartzes, we soon find ourselves across the borders of the known, and I feel inclined to transfer to quartz an observation by Dr. Sorby on granite, viz., that there are many things connected with it about which we know much less than is desirable.

I believe that the most important paper on the subject is still Dr. Sorby's short address of four pages to the Microscopical Society in 1876, "On the Critical Point in the Consolidation of Granitic Rocks." So far as I am aware, there are only two points in that paper that have been reconsidered, and neither of them are of material importance, so far as regards vein-quartz. Dr. Sorby followed Cagniard de la Tour in taking 412 C. as the critical temperature of water, whereas Mr. Hartley, in the Report to the British Association in 1877, treats it as being 342° C. Dr. Sorby also assumed that above the critical temperature water-vapour would cease to act as a solvent, whereas according to subsequent experiments it appears to do so.[1] This, of course, is a most important point as regards the consolidation of minerals other than quartz; but fortunately all the authorities appear to agree that the quartzes of granites consolidated under 342°; and probably no one would maintain that the quartzes of veins represent a temperature as great as that of granitoid rocks. If all this be true, the question of vein-quartzes is very much simplified. Liquid water will dissolve a variety of minerals which water-vapour under 342° C. will reject and deposit. With water-vapour over 342° C. we need not *ex hypothesi* concern ourselves—fortunately for the length of this paper.

Writing of the variation in the proportional contents of cavities, Dr. Sorby has this very weighty passage, viz.: "The very great variation in the relative amount of water and liquid carbonic acid in the cavities clearly proves that very great changes in the surrounding circumstances sometimes took place, even during the growth of one single crystal; and there is good reason to suspect that there may often have been considerable variations in temperature and pressure, as well as in the relative amount of water and gas" ("Critical Point," etc., R. Micr. Soc., 1876). In 1889 and 1890 I wrote two papers on the granite question, and Dr. Sorby, when acknowledging receipt of one or other of them, remarked, "I very much agree with what you have said in your paper, and it now seems to me that the conditions when granite was consolidated were very complex in some cases, even more so than I urged in my paper." This view has been wonderfully confirmed by the rock Trowlesworthite, which indicates fluoric, boracic, and phosphoric acids, a regular jumble of water and brine, and two tourmalines, one probably above and one certainly below the critical temperature of water.

With respect to the evidence borne by cavities that the temperature was over 342° C., we may cite Mr. Hartley:—"In a colourless and clear topaz there were discovered thousands of perfectly cylindrical tube-like cavities, round at each end. In the case of fifty-two cavities . . . . they each contained the same proportions of carbonic acid liquid, carbonic acid gas, and water. Hence at the time they were enclosed in the mineral, these fluids must have existed in the state of a homogeneous vapour. This of necessity places the temperature of formation of the mineral somewhere above 342° C., the critical point of water" (Rep. Brit. Assoc., 1877, p. 236).

The general conclusion seems to be as follows:—

Fluid inclusions with deposited crystals are clear proof that the fluid was entangled in the quartz or other mineral, under 342° C.

Water inclusions with variable proportions of water and vacuity were also formed under 342° C.

Groups of inclusions with proportionate amounts of water and liquid carbonic acid prove a temperature exceeding 342° C.; but with disproportionate amounts of water and acid they indicate a temperature below 342° C.

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[1] J. B. Hannay: Proc. R.S., 1881, p. 321.

Groups of water inclusions with proportionate amounts of water and vacuity may indicate a temperature over 342° C.; or unchanged conditions of heat and pressure during the crystallization of the including mineral, under 342° C. Pure water would suggest the first, while the presence of brine or dissolved salts would prove the second. A paper read by me at the Belfast Meeting of the British Association was founded on the idea of the heating of a district in the presence of water, with the result of forming hydrous minerals, and fluid inclusions in the altered rocks. But this was only a variant of a forgotten warning of Dr. Sorby twelve years before, viz.: "There is a point which should not be overlooked (I forget whether I alluded to it in my paper), and this is, that a rock formed under one set of conditions may have been exposed to others, and thus the state of the cavities may indicate the change produced by a reheating of rock." This seems to lead to a curious possibility, viz., that a crystal of quartz might catch up fluid with various salts in solution, such as soda, potash, and magnesia, and that on a strong reheating of the crystal the said minerals might enter into combination with the silica and form microlites. It is not uncommon to see a fissure in a crystal cemented with a brown iron oxide, which, if hydrous, would account for a good deal of water.

My collection of slices of vein-quartz is too small for any useful purpose except to indicate possibilities; but, so far as the slides go, they are very instructive. Specimens collected between Dartmouth and the Start contain one or more of such minerals as chlorite, epidote, fibrous hornblende, and triclinic felspar. Then on Dartmoor and its borders specimens of rock may be found showing every gradation from the simple quartz-vein, through veins composed of quartz-tourmaline and quartz-tourmaline-felspar (triclinic), to the quartz-felspar-tourmaline rock of normal granitic structure. In all these rocks the varying proportions of water and vacuity, and, above all, the ubiquitous presence of dissolved salts, indicate a temperature well under 342° C. One very eccentric slice from a vein in a greenstone presents the appearance of a typical satiny quartz, but under the microscope it is seen to contain innumerable water inclusions and carbonic acid inclusions. It also contains a small crystal of plagioclase, and exhibits throughout the curved shadows of a felspar. Observing that there seemed two varieties of quartz-veins near the Bolt Head, I ascertained that one was very full of fluid inclusions and the other unusually free from them. Possibly one represents the era of metamorphosis, and the other may be either older or later.

So far as I can ascertain, no one has worked the vein-quartz problem, or at any rate has published the results. Dr. Sorby showed in his first paper that the inclusions in quartz-veins in the neighbourhood of granites were intimately connected with the inclusions in the granitic quartzes themselves, but I am not aware that he has anywhere described the differences between quartz-veins of different ages and which have been subjected to different conditions. Nearly all my quartz slides are post-Devonian, and possibly post-Carboniferous, and they differ greatly from the quartzes in Culm grits and conglomerates, and from a conglomeratic grit which, according to Mr. E. B. Tawney, is either Cambrian or Archæan. The latter is emarkable for the uniform minuteness of the fluid inclusions, and or the almost universal activity of the bubbles. For all I can see, I cannot doubt that a careful study of quartzes of different ages would furnish much useful information, bearing both on the age and origin of sands and on the origin of crystalline rocks.

There are at present so many well-trained petrologists that perhaps it is not too much to hope that some young aspirant to fame will secure a small grant for expenses, collect quartz-veins of every obtainable age, and exhaust all the information that can be squeezed out of them. The most important papers on the subject after Dr. Sorby's classic paper in the Q.J.G.S. of 1858 are the same author's address to the Microscopical Society in 1876, and Mr. Hartley's papers on fluid inclusions to the Royal and Chemical Societies and his Report to the British Association in 1876 and 1877. Perhaps the chief thing to bear in mind as a spur to attack these much shirked problems is Dr. Sorby's final word, viz., "there are many things connected with [the subject] about which we know much less than is desirable."

VI.—THE USE OF A GEOLOGICAL DATUM.

By BEEBY THOMPSON, F.G.S., F.C.S.

A PROPER interpretation of some geological phenomena requires that allowance shall be made for differential earth-movements that have taken place since the period of occurrence of the events or conditions under consideration.

Present differences of level in rocks of the same age may be partly due to actual differences in depth of the sea-floor on which they were deposited, but they may also be the results of subsequent differential earth-movements either of a regional or of a local character, the latter including 'faults.'

In order to estimate the amount of displacement or differential movement, it is necessary to select a particular rock as a datum. The rock selected should combine, as far as possible, the following characteristics:—

1. It should be comparatively thin.
2. It should have a considerable horizontal extension.
3. It should combine similarity in physical characters and palæontological contents over a large area, so that uniformity of depth of deposit may be postulated.

In the district with which I am best acquainted, Northamptonshire, either of three formations would fairly well meet the requirements named above for certain purposes, viz., the Rhætic Beds, the Marlstone Rock-bed, and the Cornbrash. For a particular object I selected the Marlstone Rock-bed as the most suitable datum, and the results obtained by its use in this manner are, I think, sufficiently interesting to record, since they appear to justify the selection and the method of use.

It is fairly well known that one deep shaft and four deep borings have been made within Northamptonshire, two in search for coal and three for water.[1] The best readily available account of these is contained in a paper by the late Mr. H. J. Eunson, published by the Geological Society.[2]

Below is given an abbreviated and rearranged account of these five sections in accordance with information contained in the paper above referred to, together with certain corrections which it is the partial object of this paper to justify.

SUMMARY OF DEEP BORINGS IN NORTHAMPTONSHIRE.

Distance in feet above or below Ordnance Datum.

Name of Formation, etc.	Gayton.	Northampton, L. & N. W. Ry. (corrected).	Northampton, Kettering Road.	Kingsthorpe (old section).	Kingsthorpe (corrected).	Orton.
Surface of the ground	+282	+191	+278	+374	+374	+374
Top of the Middle Lias	+274	...	+107	+164	+108	+326
Top of the Rhætic Beds (White Lias)	−299	−405	...	...	...	−292
Top of the Trias (including Littoral Beds)	−335	?	−460	−486	−486	−314
Old Land Surface...	−417	−455 ?	−527½	below −593	below −593	−341
Top of the Carboniferous Formation	−417	−455 ?	−527½			
Top of the Old Red Sandstone ? ...	−607					
Top of the Archæan Rocks ...	...	...	...	...	...	−341
Bottom of section	−712	−459	−573	−593	−593	−415

Thickness in feet.

Superficial deposits	7	26	4	206	266	10
Oolitic Beds	...	...	14			
Upper Lias	1	...	153			38
Middle and Lower Lias	573	570	567	654	594	618
Rhætic (including Littoral Beds of Rhætic age)	36	50	67½	107	107	22
Trias (including Littoral Beds of Triassic age)	82					27
Lower Carboniferous Rocks ...	190	4	45½			
Old Red Sandstone ?	105					
Archæan (volcanic rock)	...	...	...	...	...	74
Total thickness	994	650	851	967	967	789

In the preceding Summary of Borings I have grouped various beds together where there might be a difference of opinion as to their individual limits, and where so doing does not affect the objects of this paper. For instance, in three of the sections—

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[1] For convenience we will speak of all as borings.

[2] Henry John Eunson, F.G.S., "The Range of the Palæozoic Rocks beneath Northampton": Quart. Journ. Geol. Soc., vol. xl, pt. 3, No. 159, pp. 482–496.

Gayton; Northampton, Bridge Street; and Northampton, Kettering Road—the Middle Lias is described in Mr. Eunson's paper as "Middle Lias (rock-beds)," and the thicknesses are given as 20, 20, and 21 feet respectively; all below, for some 550 feet, coming under the title Lower Lias Clay. No doubt, actually, the Middle Lias, that is to say, all beds between the 'Capricornus' zone below and the 'Serpentinus' zone above, is close upon 100 feet thick, but no information is available to fix the lower limit precisely in any of the borings.

The Littoral Beds are of somewhat different ages in the different places, but have been grouped with the Trias or the Rhætic for convenience.

Firstly, on reference to the Summary of Borings in Northamptonshire, it may be observed that whilst the Old Land Surface now varies in height by more than 252 feet, the variation in thickness of the rocks between it and the top of the Middle Lias only reaches 66½ feet plus so much more as would require adding on to the 252 feet also.

Secondly, it will be noticed that the Old Land Surface is lowest where the Rhætic beds have not been detected, which appears rather singular. Mr. Eunson observed this, and made the following remark thereon (p. 494): " . . . but the Kettering-road boring shows a great depression. This may partly account for the absence of the White Lias and Rhætic, and the sandy appearance and uneven bedding which the lower part of the Lias Clay presented in this boring, and which was not noticed at either Orton or Gayton."

My inability to understand in what way a quite local depression could lead to an entire absence of certain characteristic marine beds developed to a thickness of 36 feet within about five miles (Gayton), and to sandy conditions of the Lower Lias, led me to make the following simple calculations. Assuming that the well-marked Marlstone rock-bed was deposited under uniform conditions as to depth within the area under consideration, and taking it as a datum, then, according to the figures quoted in the Table of Borings, relatively to Northampton, Gayton has since been raised 167 feet and Orton 219 feet. A correction made on this basis altogether changes the appearance of things. The Old Land Surface at Northampton, instead of being 110½ feet *lower* than at Gayton and 186½ feet *lower* than at Orton, becomes 56½ feet and 32½ feet *higher* than at these places respectively. The following table will graphically show this.

Of course, in an argument of the nature here presented, it is impossible to say how much of the difference of level is due to upward movement of one place, and how much to depression of another with which it is compared; therefore the selection of a section for reference is arbitrary. Having selected the Kettering Road boring, Northampton, we will make a few comparisons between this and each of the others, together with some observations arising out of them.

TABLE SHOWING VARIATIONS OF LEVEL DUE TO EARTH-MOVEMENTS.

	Height from Ordnance Datum in feet.		
	Gayton.	Northampton.	Orton.
Present actual levels: top of Middle Lias	+274	+107	+326
,, ,, Old Land Surface	−417	−527½	−341
Restored relative levels: top of Middle Lias	+107	+107	+107
,, ,, Old Land Surface	−584	−527½	−560
Significant records	Rhætic Beds, 36 feet.	No Rhætic Beds.	Rhætic Beds, 22 feet.

Gayton.—After having made our correction for earth-movements subsequent to the Middle Lias period, if we pile the 82 feet of Trias and Littoral Beds on to the Old Land Surface at Gayton, and the 67½ feet of similar beds on to it at Northampton, it will still leave Northampton 42 feet the higher, an amount of difference in level sufficient to entirely exclude the 36 feet of normal Rhætics found at Gayton only about five miles away, in strict accordance with our specification of a datum rock, though very probably the upper portion of the Littoral Beds at the Kettering Road are of Rhætic age. The addition of 36 feet of Rhætic beds at Gayton would, however, bring the levels of the two localities, Gayton and Northampton, within 6 feet, consequently this is the amount of difference in aggregate thickness of the Middle and Lower Lias at the two places (see Table). A very small amount, it will be observed, out of 570 feet, considering that the places are about 5 miles apart.

Northampton (Kettering Road).—It follows from the above considerations that the Littoral Beds at the Kettering Road boring, Northampton, may be of an age extending from the Triassic, through the Rhætic, even into the Lower Liassic periods. This will help to explain the abnormal character of the deposits themselves, and also the sandy nature of the lower beds of the Lower Lias there, for, no doubt, land remained exposed and the sea shallow to a still later period than at Northampton, not far away.

Northampton (London and North-Western Railway, Bridge Street Station).—The account of this boring left by the Rev. C. H. Hartshorne[1] runs as follows:—

	feet.
Superficial accumulation, consisting of detrital gravels, dark tenacious clays with erratic boulders	46
Lias blue clay with bands of stone	550
Very hard pyritous rock	1
Variegated sandstone (viz., red, green, and white), with 15 feet of limestone	46
White sands	3
Magnesian limestone	4
Total	650

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[1] Rev. C. H. Hartshorne: "A Report on the Drainage of the Nene Valley"; Northampton, 1848.

Salt water came from the bottom of the boring and rose to within 8 feet of the surface.

This boring is situated about two miles from the Kettering Road boring, and in a nearly direct line between the latter and Gayton boring. It is on the south side of the Nene 'fault,' and not far removed from it; also, notwithstanding that the Marlstone rock-bed is not present, or at least was not recognized, I am convinced that the Middle Lias is nearly complete, the upper part being represented by what is described above as "dark tenacious clays with erratic boulders" to the extent of about 20 feet out of the 46 feet. This belief is founded on personal inspection of material brought up from a well on the same side of the Nene 'fault,' starting at approximately the same level above O.D. and only about a quarter of a mile away to the north, at Messrs. Phipps' Brewery, and from the fact that at two places a little nearer the line of the river Nene alluvium and gravel combined had the thickness of 27 feet and 28 feet respectively.

Referring again to the same section, when it became evident that the combined thickness of Middle and Lower Lias was nearly identical with the thickness of the same formations at Gayton (see Summary of Borings), then also it became highly probable that the *very hard pyritous rock*, 1 foot thick, immediately under the Lower Lias was the equivalent of the *hard white limestone with pyrites*, 1 foot thick, similarly situated at Gayton,[1] both, in fact, constituting the top of the White Lias.

Levelling each of these rocks to a Marlstone datum of + 107 feet O.D., as in previous instances, we get the Gayton hard limestone coming out as —466 O.D., and the Northampton, Bridge Street, hard pyritous rock as —463, or a few feet below this if we make allowance for the slight imperfection of the Middle Lias there. Anyway it is obvious that these rocks were deposited at practically the same depth at the same time. Thus the Rhætic beds are virtually brought into Northampton, and the suggested cause of their absence in normal form two miles away, at the Kettering Road boring, is made a certainty.

Orton.—After correcting for the post-Liassic earth-movements (p. 218), and placing on to the Old Land Surface at Gayton 118 feet, and at Orton 49 feet (aggregate of Trias, Littoral Beds, and Rhætics), then the top of the Rhætic beds at Orton would be 45 feet lower than at Gayton; and it might be asked why, in accordance with the gist of this paper, the whole of the Rhætics are not present at Orton, or inversely why any whatever are present at Gayton. I cannot here deal with the whole subject involved in an answer to such a question, but chiefly and briefly my reply is this:—Orton, at the close of the land period, was *higher* than Gayton (smaller thickness of Trias and Littoral Beds); at the latter end of the Rhætic period at about the *same level* (indistinguishable nature of some of the deposits from the two places);

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[1] Henry John Eunson, F.G.S., "The Range of the Palæozoic Rocks beneath Northampton": Quart. Journ. Geol. Soc., vol. xl, pt. 3, No. 159, p. 486.

in Lower Lias times *lower* (greater combined thickness of Middle and Lower Lias), because it, i.e. Orton, lay further to the north-west of that line or direction about which, as a fulcrum, a general north-westerly sinking was taking place at the time under consideration, than either Gayton or Northampton.

The almost identical thickness of combined Lower and Middle Lias at Gayton and Northampton would lead us to judge that these places were actually on the line of fulcrum, or one parallel to it, and since they are almost accurately south-west and north-east of each other respectively, that direction may be looked upon as the general direction of the axis of movement.[1]

Kingsthorpe.—The shaft at Kingsthorpe was made in a search for coal, in 1836. According to the late Mr. S. Sharp, F.G.S.,[2] "No accurate detailed section of the shaft was taken at the time; but at a depth of 210 feet from the surface, a water-yielding 'limestone rock' in the Middle Lias (Marlstone) was pierced, which produced 36,000 gallons of water per hour. At a depth of 880 feet (as is stated in pencil notes on a diagram in my possession, which notes are said to have been made by Dr. William Smith, 'the Father of English Geology') the New Red Sandstone was reached, and a flow of brackish water of a like volume to the former occurred."

It is quite certain that the above description of the Kingsthorpe shaft is in error somewhere, for, taking the figures as they are given, (*a*) of the 210 feet down to and through the rock-bed of the Middle Lias, the Upper Lias would absorb 180 feet or more, leaving less than 30 feet for all beds between it and the Great Oolite Limestone, whereas in the near neighbourhood they are considerably more than twice this thickness; (*b*) the top of the Middle Lias appears as 57 feet higher than at the Kettering Road boring; (*c*) the Middle and Lower Lias have an aggregate thickness of 654 feet compared with 567 on the Kettering Road, a difference of 87 feet in just over a mile.

Applying the Marlstone datum to Kingsthorpe, the results come out as below. Take + 107 feet O.D. as the top of the Marlstone rock-bed at Kingsthorpe, the same as at the Kettering Road boring quite near, and we get 267 feet (374 — 107) as its depth; give the rock a thickness of 4 feet, and it is evident that it would be pierced at 271 feet from the surface. In 1881 the Kingsthorpe shaft was opened up by my advice, to see if it were yielding any water from the Marlstone at 210 feet or thereabouts; it was not, but salt water filled the shaft to within 270 feet of the surface exactly. Putting these two items together, the inference is very forcibly driven home that someone has mistaken 270 for 210 in reading the records of the shaft, a thing very likely to happen.

Personally, I have no doubt that the error suggested above occurred, because, after making the correction, the general accuracy of the original record of the Kingsthorpe shaft becomes very probable; all difficulties of interpretation are removed; and we can give to the various formations their necessary thicknesses and reasonable positions above O.D.

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[1] See also "The Victoria History of the Counties of England: Northamptonshire," Geology, vol. i, p. 8.

[2] "Note on a futile search for Coal near Northampton": GEOL. MAG., Vol. VIII, p. 505.

The fact that in 1881 salt water filled the Kingsthorpe shaft to within 270 feet of the surface is suggestive; it would indicate that the Marlstone rock-bed then determined the height to which the water could rise, and, therefore, that salt water was then feeding the Marlstone to some extent; indeed, it is almost certain that, according to the amount of pumping going on at Northampton, the Kingsthorpe shaft may feed or be fed by Marlstone water. Fortunately, the supply of salt water is very moderate, and the greatest variation in chlorine I have observed in the Marlstone water is 1·61 grains per gallon. In 1879, when Marlstone water was used almost exclusively for the town supply, the water yielded 5·6 grains of chlorine and 50·5 grains of solid matter per gallon; in 1897, when it was used intermittently, the chlorine came out as 3·99 grains per gallon, and solid matter 48.

Before giving a revised section of the Kingsthorpe shaft, I must justify another alteration to be made in the figures, etc. The *Mining Journal* of September 3rd, 1854, in a description of the Kingsthorpe undertaking, after giving an unintelligible classification of the beds above, says that the Lias formation "was followed by 84 feet of New Red Sandstone, 13 feet of Red Marl, and 15 feet of Conglomerate." This description was quoted in the 1854 prospectus of "The Northampton Great Central Coal Mining Company."

Mr. Sharp, in one place, says[1] that the *blue clay of the Lower Lias was pierced at* 860 *feet,* and is stated to have been succeeded by 80 feet of Sandstone, 12 feet of Red Marl, and 15 feet of Conglomerate; in another[2] he says that *at* 880 *feet the New Red Sandstone was reached.* My opinion is that all three descriptions are essentially correct, and that the difference of 20 to 24 feet of beds, which the geologists could not decide what to call, is the equivalent of the Littoral Beds, 27 feet thick, above the Trias at the Kettering Road boring, about which, and other beds below, Mr. Etheridge said, "no equivalents in Britain," "no series like them" (Eunson, p. 484). That these undefined beds at Kingsthorpe contained conglomerates is evident, for in Miss Baker's collection of fossils was a specimen of conglomerate consisting of limestone pebbles in a greenish, sandy, and highly calcareous matrix, some parts hard and crystalline, labelled "Top of Red Sandstone *upwards* of 900 feet, Kingsthorpe shaft," a label which until recently I could not understand.

In the revised section given below, the Upper Estuarine Beds, Lower Estuarine Beds, and Ironstone Beds (not all ironstone, however) are given to the nearest foot from the record of a well recently made (1902) just over one mile away to the east.

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[1] "The Oolites of Northamptonshire," part i: Quart. Journ. Geol. Soc., March, 1870.

[2] "Note on a futile search for Coal near Northampton": Geol. Mag., Vol. VIII (1871), p. 505.

Old Section.	Thickness in feet.	Revised Section.	Thickness in feet.	Depth of base in feet.	Height of top from O.D.
Rocks down to and through the Rock-bed of the Middle Lias	210	Superficial Beds	8 ?	...	+374
		Upper Estuarine Beds...	26		
		Lower Estuarine Beds...	31		
		Ironstone Beds (stated to be 35 feet)	21	86 ?	
		Upper Lias	180 ?	266 ?	+288 ?
Middle and Lower Lias	650	Middle Lias	100 ?	366 ?	+108 ?
		Lower Lias, with stone bands towards the base	494 ?	860	+8
Sandstone ...	80	Littoral Beds, including conglomerates	20	880	−486
		Red Sandstone	60	940	−506
Red Marl ...	12	Red Marl	12	952	−566
Conglomerate	15	Conglomerate	15	967	−578
	967	Total depth ...	967		

In conclusion, it may be pointed out that, beyond the direct object of the paper, several little points in local geology have been cleared up or made more intelligible. Perhaps the most generally useful result is the demonstration that a levelling up process was going on just before the commencement of the Lower Liassic period, which culminated in the Rhætic beds (White Lias), and that a similar levelling took place at the close of the Middle Lias period, though this was perhaps as much a result of redistribution of material in shallow water, a give and take process, which ultimately led to the very uniform conditions of the 'Acutus' zone (Transition bed) at the top of the rock-bed of the Middle Lias.

VII.—NOTE ON THE MILLSTONE GRITS OF GRASSINGTON MOOR.

By J. R. DAKYNS.

THE Millstone Grits of Grassington consist, speaking generally, of the beds given in the following table, viz. :—

Grit of Henstone Band.
Measures.
Thin limestone.
Redscar Grit.
Measures.
Sandstone.
Measures.
Sandstone of Priest Tarn.
Measures.
Coal and shale.
Top Grit of Grassington Moor.
Shale and coal.
Bearing Grit of Grassington Moor.

As throughout the greater part of Upper Wharfedale the Bearing Grit lies immediately on or close to the Main Limestone of Phillips'

Yoredale Series, we have here a well-marked and natural division between the Yoredale Beds and the Millstone Grit.

The Bearing Grit is so called because the lead veins are very rich in this bed.

A tolerably persistent coal, ranging up to ten inches in thickness, occurs in the overlying shales, and a coal up to six inches thick lies on or near to the Top Grit.

The sandstone of Priest Tarn probably corresponds to a bed which further north forms Pinlow Pike, and is in Coverdale, though thin, very persistent and of a well-marked character, being a hard siliceous rock.

The next important rock is the bed we call the Redscar Grit. It is a coarse felspathic grit of a very red tinge, which is apt to form such conspicuous red scars that it can be recognized miles off. This rock, like the Grassington group, often consists of two members parted by a shale band containing a coal-seam, and it thus forms a double feature. In this part of the country it generally has on or near its top a thin bed of peculiar limestone that has the appearance of a tesselated pavement. This tesselated limestone forms a very good horizon as the top of the rock, which we correlate with the top of the Kinder Scout Grits.

The next important rock is that which forms Henstone Band. We correlate it with the lower grit of Follifoot Ridge.

I will now briefly describe the run of the principal beds. Immediately north of the Craven Fault the Lower Millstone Grits strike west from Bewerley across Grimwith Fell towards Grassington. Near this village they turn north and run by the mines across Grassington Moor, Black Edge, and Coniston Moor. They are thrown down to the north of Yarnbury by the New Rake Vein, then up by Beaver Vein, and after several small breaks are finally thrown up on the north by the Bycliffe or Black Vein.

This great vein runs from Bycliffe along Groove Gill, crosses Gateup Gill, where the fracture is seen, and thence crossing north of Wigstones it runs down Stony Groove to Merrifield, and thence into the Craven Fault near Pateley Brig. This vein is the most northerly and greatest in throw of the many veins on Grassington Moor. They seem all to be more or less connected with the Craven Fault, to which they are roughly parallel or with which they make small angles.

The Redscar Grit occupies the northern part of Appletreewick Moor and Hebden Moor. It forms a fine escarpment along the sides of Gateup Gill. It is thrown up to the north by the Bycliffe Vein so as to form the escarpment of Rather Standard, at the north end of which it is thrown up on the west, so that the top of the rock, which runs up Henless Beck, is now found in Meugher Dike. This top is well marked by the tesselated limestone which is found in place in Henless Beck and in Meugher Dike.

The rock forming Sand Haw seems from its position to be part of the Redscar Grit. It is a peculiar rock, being hard, close-grained, and siliceous, and is used for making whetstones, for which purpose it is, or used to be, transported for long distances. It is somewhat similar to the Redscar Grit of Wolfry Crags, but is quite unlike the general character of this bed.

It is noteworthy that I found near the base of the Redscar Grit in Gateup, bands of calcareous sandstone. Similar bands, as I am informed by Mr. J. G. Goodchild, generally occur under the rock which in Wensleydale was identified on purely stratigraphical grounds with the Redscar Grit.

This grit is the 'middle grit' of the late Professor Phillips mentioned on p. 65 of his "Geology of the Mountain Limestone District," and he is quite correct in saying that it corresponds in position with the top grit of Penhill.

NOTICES OF MEMOIRS, ETC.

ON THE EVOLUTION OF THE PROBOSCIDEA. By C. W. ANDREWS, D.Sc., F.G.S., F.Z.S., of the Geological Department, British Museum (Natural History).[1]

UNTIL the author's recent discoveries of primitive Proboscidea in the Middle and Upper Eocene formations of the Fayum, Egypt, the oldest known members of this mammalian order were *Dinotherium Cuvieri* and *Tetrabelodon angustidens*, from the base of the Miocene in France. The new Egyptian fossils not only reveal for the first time the early history of the order, but also provide more satisfactory material for the discussion of its evolution than has hitherto been available.

The most important changes in the Proboscidea occur in the skull, mandible, and dentition.

Owing to the increase in the size of the tusks and to the presence of the proboscis, the facial region of the skull becomes shortened, and at the same time the premaxillæ become wider. The presence of the proboscis also accounts for the position of the external nares. The demand for a greater surface of attachment for the muscles supporting a skull rendered heavy by the tusks and trunk, is met by the great development of the diploë in certain of the cranial bones, resulting in the enormous expansion of the forwardly sloping occipital surface. The maxillæ become greatly enlarged concomitantly with the increase in the size and degree of hypselodonty of the molars. At the same time the zygomatic arch becomes weaker and the jugal takes a smaller share in its composition.

The mandible is at first short and stout, with a massive symphysis. Afterwards it becomes more and more elongated as the stature of the animals increases; and this elongation is for the most part effected by the lengthening of the symphysial region, though the backward rotation of the ascending ramus tends to the same end. The prolongation of the mandible beyond the premaxillæ must have been covered by a proboscis-like structure composed of the upper lip and nose, probably more or less prehensile at its extremity.

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[1] Abstract of a paper read before the Royal Society of London, March 26th, 1903; communicated by Professor E. Ray Lankester, F.R.S.

The lengthening of the mandible seems to have reached its maximum degree in the Middle Miocene, after which it again became shortened by the reduction of the symphysis, while the fleshy and now mobile proboscis was left behind as the sole organ of prehension.

In the upper dentition the chief changes are the loss of incisors Nos. 1 and 3, and the great increase in size of incisor No. 2, which eventually forms the great tusk characteristic of the later Proboscidea. The canines are soon lost. In the earliest forms, some at least of the cheek-teeth (milk-molars) are replaced by premolars in the usual manner, and these teeth remain in wear simultaneously with the true molars; but in later forms no vertical succession takes place, and as the milk-molars are worn they are shed, being replaced from behind by the forward movement of the molars. Of these also the anterior may be shed, until at length in old individuals of the later types the last molar is alone functional. The gradual increase in the complexity of the proboscidean molars is one of their most striking characteristics. All stages can be traced between the simple, brachyodont, bilophodont (quadritubercular) molars of *Mœritherium* (Middle Eocene) to the extraordinarily complex type of tooth found in *Elephas.* Thus in *Palæomastodon* (Upper Eocene) the molars are trilophodont, and the same is true of the first and second molars of *Tetrabelodon* (Miocene), in which, however, the last molar is complicated by the addition of further transverse crests. In the Stegodonts of the Siwalik Hills (Pliocene) a further increase in the number and height of the crests takes place, and the whole crown of the tooth is more or less covered with a thick coat of cement. Still later, the transverse crests become highly compressed laminæ united by cement, and these are as many as twenty-seven in number in the Pleistocene *Elephas primigenius* and the recent *E. indicus.*

The evolution of the lower molars corresponds with that of the upper molars. Of the lower incisors the middle and outer pairs (Nos. 1 and 3) are soon lost, but the second pair remains functional for a long geological period. When the symphysis becomes shortened, these incisors are sometimes retained as vestiges (e.g. in *Mastodon americanus*), but in the genus *Elephas* they have completely disappeared.

REVIEWS.

I.—Chart of Fossil Shells found in connection with the Seams of Coal and Ironstone of North Staffordshire. By Wheelton Hind, M.D., F.R.C.S., F.G.S., and John Stobbs, F.G.S. (Published by the North Staffordshire Institute of Mining and Mechanical Engineers, 1903. Price 5*s.*)

It is an acknowledged fact that, compared with many other commercially less important geological formations, very little is known about the distribution of the fossils among the Coal-measures. In this respect the North Staffordshire Coalfield has been more carefully searched than others, though outside the district this typical Midland coalfield is not so well known as the excellence of the sequence and preservation of its organic contents warrant. The chart by Messrs. Hind and Stobbs should draw attention to this region, for besides being of use to the mining student it will be found to be of more than local value, and should be studied by all interested in the Coal-measures.

The chart gives the order of sequence, distance apart, and synonyms of the seams of Coal and Ironstone of the Pottery and Cheadle Coalfields, in two sections drawn on a scale of 200 feet to the inch. The fossil shells distinctive of or especially abundant on certain horizons are drawn opposite to the particular bed in which they occur. No attempt has been made to subdivide the Coal-measures beyond the use of merely local terms for the higher portion of the sequence. Marine organisms are represented as occurring on three horizons—at the base, near the middle, and towards the summit of the coal-bearing strata. A noticeable omission, evidently due to extreme caution, is the band, rich in marine organisms, found many years ago by Mr. John Ward above the Gin Mine at Longton. Thin limestones with *Spirorbis*, so long held to be distinctive of the higher Coal-measures, are represented at two horizons low in the sequence. The fossils are clearly drawn, while their selection by Dr. Wheelton Hind guarantees that the typical forms have been chosen.

The authors have evidently taken great care in planning and drawing up the chart: it is to be hoped the Mining Institutes in other coalfields will follow the example of that of North Staffordshire by publishing similar charts, and thus show that they recognize the close union of the two sciences of Mining and Geology.

WALCOT GIBSON.

II.—CAPE OF GOOD HOPE. ANNUAL REPORT OF THE GEOLOGICAL COMMISSION, 1900. 4to; pp. 93. (Richards & Sons, Cape Town, 1901.)

I. The results of the survey of parts of the Uitenhage and Port Elizabeth districts (pp. 1 to 18). The Sunday's River Marine Beds, the Wood-bed series, and the Enon Conglomerate series constitute the great *Uitenhage* series; and these were studied in the Zwartkop Valley, the Bezuidenhout Valley, and on the White River and the Sunday's River. The fossil fauna and flora are referable to both the Jurassic and the Cretaceous series; and are here provisionally regarded as Upper Jurassic. The occurrence of much more recent deposits near the coast are alluded to. The observations made by earlier geologists on the district are carefully noted.

II. (Pages 19–54.) A survey of parts of Clanwilliam, Van Rhyn's Dorp, and Calvinia divisions led to the definite recognition of a separate series of sedimentary rocks (shales, sandstones, vein-quartz, quartzite, limestone, and conglomerate) underlying the Table Mountain Sandstone, and resting on the Malmesbury series. The conglomerates are decidedly glaciated, and much resemble those of the Congo in Oudtshoorn in some respects. The sandstones, false-bedded and ripple-marked, show worm-casts and definite animal trails. This *Ibiquas* series (named after a local tribe of natives) extends from the north-eastern part of Van Rhyn's Dorp district into Calvinia; it appears to be much thicker than the Bokkeveld series, which in places is seen to be unconformable above it.

In this survey we have also an account of the local range of the Table Mountain Sandstone, the Bokkeveld Beds, the Dwyka series, and its continuation to Prieska and Hope Town. The peculiar *White Band*, lying on the Dwyka Conglomerate, owes its appearance to the slow combustion of a carbonaceous shale under atmospheric agencies. The thick shales and sandstones of the Ecca series, above the White Band, contain some ferns and calamites in the south. The local dykes and sheets of Dolerite are described in detail. They all belong to one series of intrusions; and, like the Karoo dolerite type, consist of a moderately coarse plagioclase-augite-olivine rock.

III. The survey from Beaufort West to Calvinia (pp. 55 to 64) showed mostly horizontal beds of the Karoo series of shales and sandstones, pierced vertically and horizontally with dykes and sheets of the usual dolerite. The shape and constitution of the hills very much depend on the presence of this intrusive rock and the peculiar modes of its weathering. A remarkable cylindrical hole, near Ratel Fontein, in sandstone and shale, is filled with rocks and minerals such as are found elsewhere associated with diamonds, but they are absent here.

IV. (Pages 65 to 79.) The geology of the Cedarbergen and adjoining country between the Gydr Pass on the south and the Pakhuis Pass on the north comprises the Table Mountain Sandstone, the Bokkeveld, and the Witteberg series. In the Table Mountain Sandstone (Lower Devonian) of the Pakhuis Pass there is undoubted evidence of local glacial action contemporaneous with the deposition of the sandstone and shale or mudstone, with glaciated pebbles in early Devonian times.

In a separate paper on this Glacial Conglomerate in the Table Mountain Sandstone read before the South African Philosophical Society in February, 1901, Mr. A. W. Rogers gave further particulars as to the character and condition of this deposit, illustrated by a plan and section (Trans. S.A. Phil. Soc., vol. xi, pt. 4, pp. 236–242). He states that "The shale band was first recognised by Mr. Schwarz in the Hex River and Warm Bokkeveld Mountains. In the 1st Ann. Rep. Geol. Comm. C.G.H. for 1896, p. 27, he describes two shale bands, one near the Table Mountain Sandstone and the other near the bottom: the upper of these two is the one referred to above. The course of this band between the Schurftebergen and Pakhuis is described in the 5th Ann. Rep. for 1900."

The results of 1900 were obtained under very disadvantageous circumstances owing to the War, but they have been welcome additions to geological knowledge: (1) especially as to the relationship of the Ecca series and the associated so-called Dwyka Conglomerate to the formations above and below; (2) the existence of a separate formation (Ibiquas) between the Table Mountain Sandstone and the Malmesbury Schists; (3) a definite glacial conglomerate in the Table Mountain Sandstone; (4) the careful and systematic examination of the probably Upper Jurassic in the East Province round about Uitenhage confirms and gives welcome additions to what was known before.

The work has been done by A. W. Rogers and E. H. L. Schwarz. Dr. Corstorphine, while Director of the Survey, made the useful report before us, and on his resignation, we understand, was succeeded by Mr. Rogers. We have no doubt of the further good progress of this Survey. T. R. J.

III.—British Museum. A Guide to the Antiquities of the Stone Age in the Department of British and Mediæval Antiquities. Pages xii and 124, with ten plates and 142 illustrations. (British Museum, Bloomsbury: printed by order of the Trustees, 1902. Price 1s.)

MR. CHARLES H. READ, F.S.A., the Keeper of British and Mediæval Antiquities, who is the author of this admirable Guide, has conferred a great service on the ordinary Museum visitor, who "wants to know," and is at a loss to find out for himself the hidden meaning of things. He is like the Ethiopian eunuch of old and wants some man to guide him. Mr. Read kindly comes forward and at once the difficulties of understanding the collection disappear.

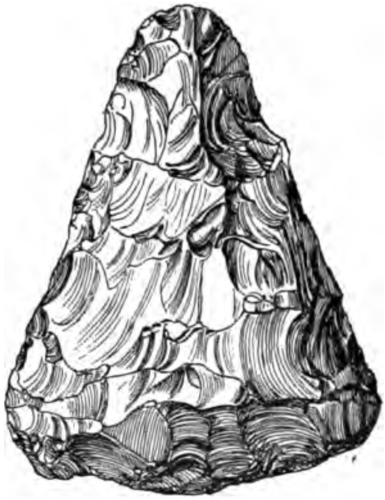

Fig. 1.—Triangular implement, Herne Bay. (Fig. 6, p. 18 in Guide.) ½ nat. size.

The period in human history represented by the 'Stone Age' is just that most difficult of all chapters to write, because the evidence is so largely inductive, and depends for the earlier or

Palæolithic period to so great an extent upon geological data, that one would naturally expect to have to pay a visit to the Cromwell Road Branch of the British Museum at South Kensington in order to understand the stratigraphical aspect of our Earth in relation to early Man as one of its inhabitants. Mr. Read, however, in the first 14 pages of his Guide, gives us an excellent resumé of the Palæolithic period, and takes us back first to the discovery by Mr. Conyers (at the end of the seventeenth century) of a flint implement, in gravel, near Gray's Inn Lane, London, together with an elephant's tooth; and then on to Mr. John Frere's researches a century later (1797), and the finding of flint implements in river gravel at Hoxne, Suffolk, which the discoverer referred "to a very remote period indeed, and to a people who had not the use of metals." No other records occur of finds in valley gravels until M. Boucher de Perthes' exploration of the deposits of the Somme Valley at Abbeville (1850), where large quantities of implements evidently fashioned by the hand of man were found.

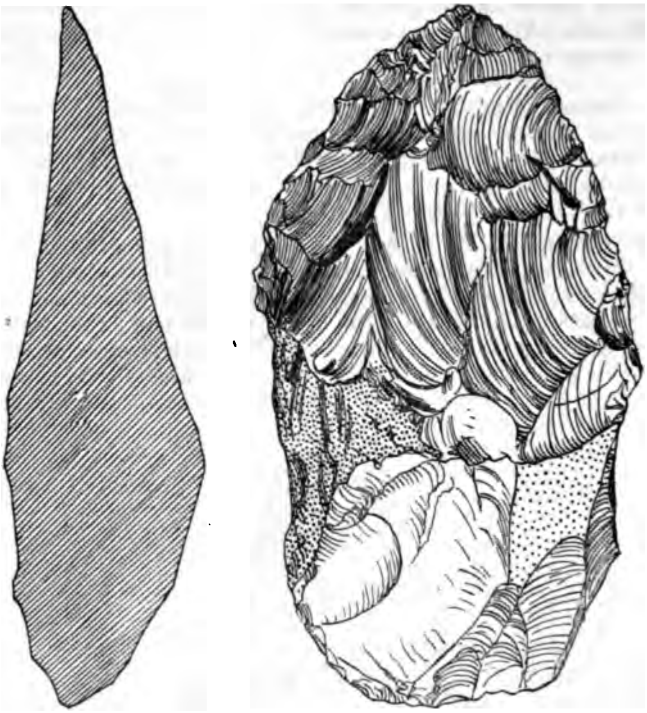

FIG. 2.—Shoe-shaped implement, Northfleet. (Fig. 8, p. 19 in Guide.) ⅔ nat. size.

It is due, however, to the Rev. J. McEnery (a Roman Catholic priest living at Torquay, S. Devon) to mention that, so far back as 1825,[1] he had discovered (*not* in river gravel, but) in Kent's Cavern,

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[1] Published by E. Vivian, Esq., 1859.

Torquay, evidences of man in the form of flint flakes and stone implements, associated with the remains of Hyæna, Reindeer, Cave-bear, and the sabre-toothed Tiger or Lion (the *Machærodus*), together with the Mammoth and Rhinoceros.

The truth of McEnery's discoveries remained unverified until forty years afterwards, when Pengelly's exploration of Kent's Cavern placed the accuracy of McEnery's original observations beyond a doubt. The stone implements sent up to Professor Buckland eighty years ago by McEnery seem to have disappeared, but the remains of *Machærodus* and Hyæna were preserved, and testify to the value of his work as an original observer and discoverer of early Man.

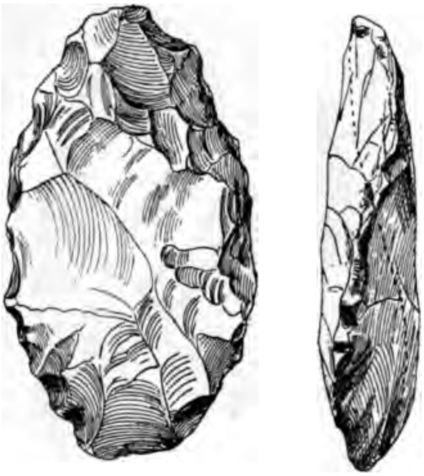

Fig. 3.—Chert implement with curved edges, Broom, Dorset. (Fig. 15, p. 25 of Guide.) ½ nat. size.

A diagram is given by Mr. Read (on p. 2) to show the evidence as to the geological antiquity of the river-valley gravels containing the flint implements in the valleys of the Somme, the Thames, and elsewhere. Contrary to other geological evidence, based upon superposition (where one would at once naturally conclude that the highest beds were the newest, and the lowest the oldest), in these river-valley deposits it is the oldest beds of gravel which occupy the highest of the old river-valley terraces, and the newest gravels which lie in the bottom of the present river valley. The explanation is so obvious that (like the story of Columbus and the egg) everyone sees it must be so, when told that the river in the course of centuries has gradually deepened its valley, and that whereas it formerly flowed perhaps hundreds of feet above its present level, it has, by its slow erosive action (aided by rain, frost, and snow), cut its channel lower and lower, until it has reached the depth at which we find it flowing to-day. But the river, in wandering in its serpentine course along its valley, leaves behind upon its flanks portions of its earlier and more elevated level in the shape of terraces covered with beds of old river-valley gravel (containing flint implements), of which the highest is really the oldest. Even outside the limits of its valley we find that still older watercourses have flowed along, and in places spread sheets of gravel over the plateau far above the reach of any modern flood-waters. In this *very ancient gravel* implements of a far ruder type than those commonly known as 'Palæolithic' are met with. These have been accepted as weapons made by some early and most uncivilized race of mankind, and are termed 'Eoliths,' good examples of which, collected by the Rev. R. Ashington Bullen, may be seen figured in Plates VI and VII of this Magazine for March last (pp. 102–110). "It is not" says Mr. Read (p. 10), "the province of the present Guide to enter into the arguments which have been brought forward against or in favor of the artificial character of Eoliths, but it may be said that whether their claims can be substantiated or not, the existence of implements of a ruder kind than those of the drift is in itself not improbable. For no invention reaches perfection suddenly, and each stage of advance is attained by an infinitely slow progress from the simple to the more

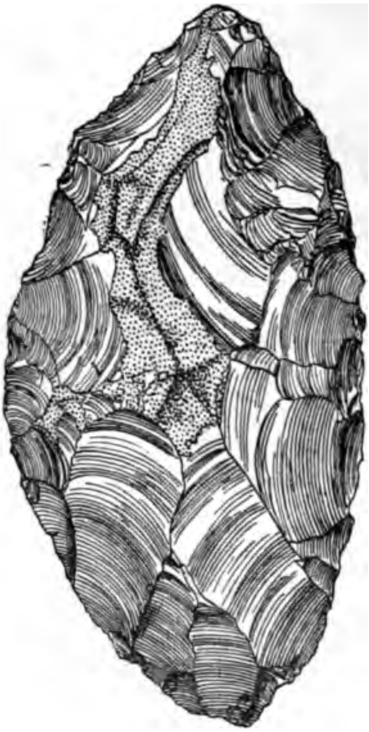

FIG. 4.—Chopping tool, province of Poitou. (Fig. 29, p. 32 in Guide.) ½ nat. size.

complex. The majority of the drift implements are clearly something more than the first efforts of an unpractised hand; they show, on the contrary, signs of a comparatively long development, and it may be fairly argued that their ruder prototypes must exist somewhere.

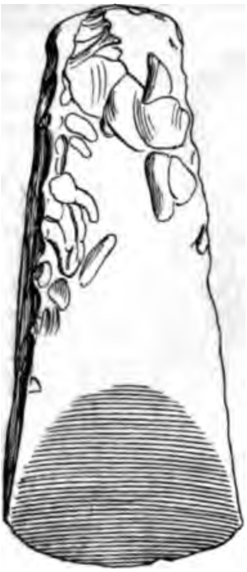

Fig. 5.—Axe-head with hollowed edge, Denmark. (Fig. 96, p. 89 of Guide.) ¾ nat. size.

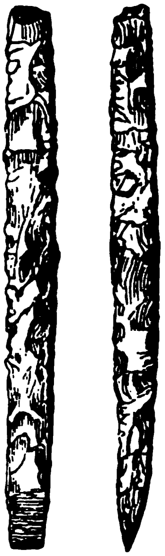

Fig. 6.—Flint chisel, Denmark. (Fig. 97, p. 89 of Guide.) ½ nat. size.

It was to be expected that they should have escaped notice for a longer time than the typical Palæoliths, if only because they must necessarily be more difficult to distinguish from the naturally fractured flints.

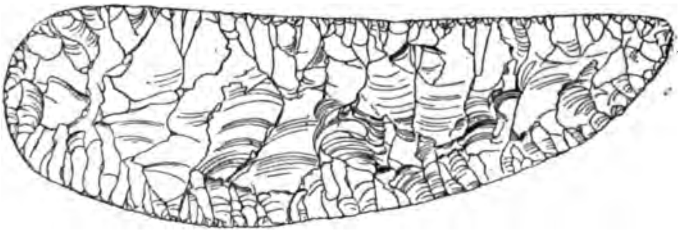

Fig. 7.—Chipped knife of chert, Sheikh Hamadeh, Egypt. (Fig. 101, p. 95 of Guide.) ½ nat. size.

"We may draw similar conclusions from a consideration of the stone implements of the most primitive savage tribes. The knives of the now extinct Tasmanian aborigines were of the rudest description, generally chipped only on one side, and quite devoid of symmetry. The Andamanese had implements of a yet more elementary kind, and the Semang, a similar negrito tribe of the Malay Peninsula, are said only to have stone implements in the sense that they pick up and use such convenient fragments as they may chance to find, usually employing shell, bamboo, or wood to provide for their simple needs. There are therefore still in existence peoples to whom, from climatic and other reasons, stone implements are of only secondary importance; and though their civilization is low, it must be higher than that of the earliest representatives of the human race. Yet supposing the negrito tribes had died out before their countries had been discovered by Europeans, the extremely rough character of their stone tools would probably have led anthropologists to reject them as of human

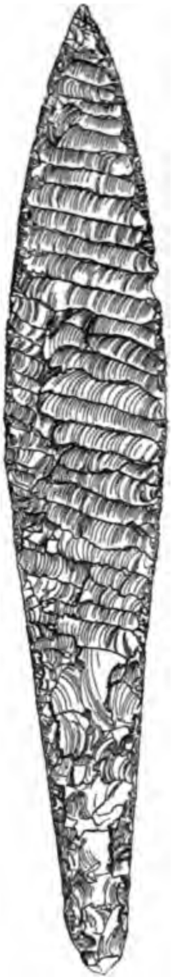

Fig. 8.—Flint knife, Denmark. (Fig. 115, p. 103 of Guide.) ⅓ nat. size.

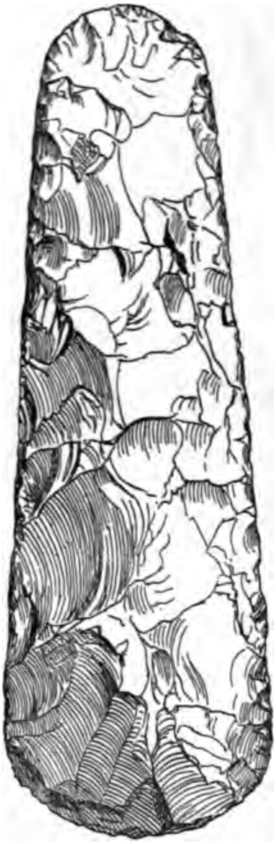

Fig. 9.—Unground axe-head, Hitcham, Bucks. (Fig. 121, p. 106 of Guide.) ½ nat. size.

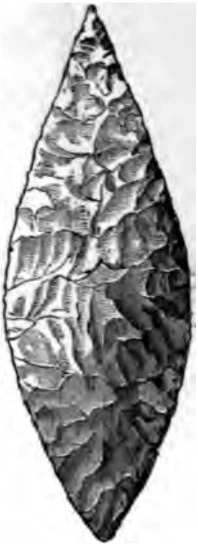

Fig. 10.—Flint javelin-head, long barrow, Wilts. (Fig. 138, p. 114 of Guide.)

andiwork, or to assume that they were made by anthropoid apes. he search for evidence of man's existence before the drift-gravels f the present river-systems of Western Europe were deposited is, t any rate, justified by analogy, though how long before, zoology nd anthropology must decide. What is quite certain is that the xtreme rudeness of a chipped flint is not in itself a ground for s rejection as the work of man." (p. 11.)

The time and space at our disposal will not permit us to do dequate justice to Mr. Read's excellent Guide, which must certainly ke a foremost place among such works, of which the Museums of loomsbury and Cromwell Road now possess a most admirable series.

We have borrowed only 10 out of the 199 illustrations which adorn is work, 142 being given in the text, while 57 half-tone figures ake up ten beautifully printed process plates. The illustrations e for the most part original, and give examples of weapons of ery form, country, and stage of development in the Age of Stone. olishing appears to mark the later and more advanced period of ulture, but when we examine the exquisite workmanship of the hipped and unpolished chert knives from Egypt, one is led to marvel t the very fine art in the manufacture of weapons in flint to which e ancient Egyptians must have attained before they were able to bricate such lovely knife-blades in silex. In addition to several eological sections and views of ancient and modern pile-dwellings, ere are about twenty drawings of carved bones, and pictures of nimals on bone, given to complete this charming little book on the Stone Age.'

We have but to add that the price is only one shilling and veryone, we feel sure, will buy a copy.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

.—March 11th, 1903.—Prof. C. Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read :—

1. "Petrological Notes on Rocks from Southern Abyssinia ollected by Dr. Reginald Kœttlitz." By Catherine A. Raisin, D.Sc. Communicated by Professor T. G. Bonney, D.Sc., F.R.S., F.G.S.)

The specimens described in this paper were collected by r. Kœttlitz on an expedition (in 1898–99), starting from Berbera, estward through Somaliland and Southern Abyssinia, and turning orthward to the Blue Nile. The paper gives petrological notes on e different classes of rocks represented. The crystalline rocks nclude granite, gneiss, and hornblende-schist or foliated diorite, gether with more basic types. They occur where the plateau ses from the coastal plain, farther west underlying volcanic rocks nd sedimentary strata, in the south-west of Abyssinia, and towards e Sudan. Some of the gneisses exhibit pressure effects, as if these lder masses had been thrust up. The more basic types include iabase, hornblende-gabbro, and one lustre-mottled hornblende-yroxenite, resembling a picrite.

The sandstones (which are chiefly from Somaliland and the south-east of Abyssinia) are sometimes compacted into quartzites, and are often ferruginous. Some of the limestones are concretionary, others are dolomitic, and several from different localities are fossiliferous, containing foraminifera, calcareous algæ, and, at Jigjiga Pass (which leads into Abyssinia), *Turritellæ* in great numbers.

The numerous specimens of volcanic rocks include one which is practically a limburgite, many basalts (a few with olivine, and some glassy), various less basic volcanic rocks, and several pumiceous tuffs. But the most interesting are the phonolites and allied rocks, containing nepheline, riebeckite, or other alkaline minerals. They occur at several places, one being a volcanic hill with a summit-crater. The authoress distinguishes several types among these soda-bearing rocks, and compares two of them with rocks of Central Abyssinia and of British East Africa respectively. Thus the specimens here described may form a connecting link between the volcanic rocks of other East African localities.

2. "The Overthrust Torridonian Rocks of the Isle of Rum and the Associated Gneisses." By Alfred Harker, Esq., M.A., F.R.S., F.G.S. (Communicated by permission of the Director of H.M. Geological Survey.)

The Torridonian strata of Rum occupy all the northern part of the island, together with a strip extending along the eastern coast, the high ground in the south being made by plutonic rocks of Tertiary age. The northern tract consists in general of sandstones having a moderate dip to the north-west or west-north-west, and below these there emerges on the east side a lower group composed of dark shales. There are, however, two districts in which the strata are highly disturbed and overthrust. One is a small area to the north-west, on Monadh Dubh, where a cake of thoroughly brecciated and mylonitized rocks rests on the relatively unmoved sandstones. Besides sandstone, this crushed mass contains abundant débris of Cambrian limestone, chiefly towards the base, and resting immediately upon the surface of overthrust. The limestone does not occur in place on the island.

The other and more extensive area of overthrust rocks forms a belt along the north-eastern and eastern border of the mountain tract. The effect of the displacement has been to bring the shales of the lower group to rest on the sandstones of the upper. Above the main surface of movement the shales are violently contorted, and the sandstones, where these occur, brecciated. There is also considerable thermal metamorphism, due to the Tertiary intrusions. At numerous places along the disturbed belt are patches and lenticles of gneiss. These are intrusive in the Torridonian rocks, and the evidence points to their being of Tertiary age. They have arisen in great part from a granitic magma modified in varying degree by dissolving basic, and often ultra-basic, rock-débris. The heterogeneous composition thus imparted has, with flowing movement, resulted in a well-marked gneissic banding. In a minor degree basic rocks, probably gabbros originally, have contributed more directly to the composition of the complex, namely, as bands or lenticles of rocks, now hornblendic, representing distinct intrusions enveloped and modified by the later and more voluminous invasion of acid magma.

The chief conclusions which the author wishes to establish are:—

(i) That the highly disturbed region of the North-West Highlands, already known to extend into the south-eastern part of Skye, is further prolonged into the Isle of Rum.

(ii) That at numerous places along the disturbed belt which borders the principal mountain group of the island, the Tertiary plutonic intrusions assume the character of well-banded gneisses, comprising alterations of different lithological types.

(iii) That these complex gneisses were formed mainly by fluxion in a heterogeneous mass, the heterogeneity being due to the inclusion and incorporation in a granitic magma of relics of ultrabasic and basic rocks.

II. — March 25th, 1903. — Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On a New Species of *Solenopsis* from the Pendleside Series of Hodder Place, Stonyhurst (Lancashire)." By Wheelton Hind, M.D., F.R.C.S., F.G.S.

This specimen of a perfect left valve was found by the Rev. Charles Hildreth in shales belonging to the Pendleside Series, which have yielded the following fossils: *Phillipsia Van-der-Grachtii*, *Ph. Polleni*, *Prolecanites compressus*, *Glyptoceras spirale*, *Gl. reticulatum*, *Gl. platylobium*, *Orthoceras annulosolineatum*, *Posidonomya Becheri*, *Solenopsis major*, and a few Brachiopods.

2. "Note on some *Dictyonema*-like Organisms from the Pendleside Series of Pendle Hill and Poolvash." By Wheelton Hind, M.D., F.R.C.S., F.G.S.

Mr. D. Tate discovered a specimen, in the shales and limestones in the Angram Brook, which had some resemblance to a *Dictyonema*; and he afterwards found another similar specimen, on or about the same horizon, at Poolvash. These are referred to distinct species, and doubtfully assigned to the genus *Dictyonema*. A piece of shale from the Bishopton Beds in Glamorganshire has somewhat similar but less distinctly reticulate markings.

3. "The Geology of Tintagel and Davidstow District (Northern Cornwall)." By John Parkinson, Esq., F.G.S.

The country described and mapped consists of some 22 square miles in Northern Cornwall, extending from the coast eastward towards Camelford Station and St. Clether. In the eastern part it extends to the neighbourhood of the Brown Willy mass of granite, while on the north it approaches the boundary between the Lower Culm and the Upper Devonian. The rocks described are of the latter age, and contain *Spirifera disjuncta*.

Except in the southern coast region (Tintagel and Trebarwith Strand) the strike is fairly uniform in an east-south-easterly and west-north-westerly direction, the beds having a northerly dip;

but north and south of Tintagel Head the higher members appear, greatly faulted, being brought in out of their true position partly by a change of strike, partly by dip-faults. The most distinctive rocks, utilized as a datum for mapping, are a group of ashes and lavas. The latter are often amygdaloidal, and possess original characters which are still recognizable; but the whole group is frequently much altered or entirely reconstructed, with the formation of epidote (sometimes enclosing allanite), sphene, biotite, chlorite, etc. The rocks are associated in many instances with calcite, at least partly due to contemporaneous deposition, but frequently forming a corporate part of the renovated rock, and the mineral is found with quartz and translucent felspar.

Bluish-black slates and finally laminated quartzose beds overlie and underlie this volcanic series.

The remaining rocks are phyllites, closely resembling those from the Ardennes. The author divides them into four groups. The highest of these (Tredorn Beds) overlies the uppermost division of the Blue-Black slates, and in the western part of the district contains a mineral forming small white spots, not yet determined. The beds underlying the Lower Blue-Black slates (Halwell Cottage Beds) are banded phyllites, with quartzose laminæ, typically containing abundant crystals of clinochlore with a habit resembling that of ottrelite. The underlying phyllites (Penpethy Beds and Slaughterbridge Beds) contain no distinctive mineral. Taken as a whole, the phyllites consist of a sericitic and chloritic groundmass containing unorientated crystals of white mica, micaceous ilmenite, hæmatite, and minor quantities of tourmaline and rutile. North-east of Camelford (Grigg's Down) they furnish clear evidence of contact-metamorphism.

III. — April 8th, 1903. — J. J. H. Teall, Esq., M.A., F.R.S., Vice-President, in the Chair.

Professor W. W. Watts drew attention to the exhibit on the table of the new series of Platinotype Photographs issued by the Geological Photographs Committee of the British Association.

The following communications were read :—

1. "On the Probable Source of some of the Pebbles of the Triassic Pebble-Beds of South Devon and of the Midland Counties." By Octavius Albert Shrubsole, Esq., F.G.S.

After an account of previous researches on this subject, the author proceeds to describe the Budleigh Salterton Pebble-Beds. Judging from lithological evidence, the bulk of the pebbles must have come from a definite region of a comparatively simple geological character; and this is confirmed by the palæontological evidence. The supposition is natural that Devonian rocks were once represented either in the Calvados district or in some region in the same drainage area as that which has supplied the Ordovician element. The Grès de May of Normandy and its associated rocks are next described, a massif which, according to Professor Bonney, must have exceeded the Alps in breadth. When regard is had to the extent and original thickness of the Grès de May, it appears capable of furnishing abundant material, not only for the Ordovician pebbles of the Budleigh Salterton Pebble-Bed, but also for a great deal more. A list of species common to the Grès de May, of May itself, and the Budleigh Salterton deposit is given; and it is pointed out that in the Department of the Manche the former deposit varies in palæontological facies. In addition to the identity of the quartzites and felspathic grit in the two areas, it is noted that the so-called lydianstone (tourmaline-grit) of Budleigh and the Midlands may be paralleled with one referred to by MM. de Tromelin and Lebesconte in the Department of Maine-et-Loire. The author is struck with the resemblance of the Midland Bunter to that of Devon, and he gives the percentage of rock-types in the larger pebbles at Repton and in the smaller material of Drift derived from the Bunter at two localities in the Lickey Hills. Strong family likenesses subsist between certain specimens in the northern and southern Bunter and some of the undisturbed rocks of Normandy. A list of fossils from the Midland Bunter contains three southern forms; and a further table is given comparing fossils from Drift-pebbles from Budleigh Salterton and from Normandy. Fourteen out of twenty of the Drift and Bunter fossils are found at Budleigh Salterton and in Normandy. The hypothesis which presents the least difficulty appears to be that which regards the two pebbly deposits, north and south, as having had approximately a common origin. It does not necessarily follow that both deposits are due to the same river.

2. "Note on the occurrence of Keisley Limestone Pebbles in the Red Sandstone Rocks of Peel (Isle of Man)." By E. Leonard Gill, Esq., B.Sc. (Communicated by Prof. W. Boyd Dawkins, D.Sc., F.R.S., F.S.A., F.G.S.)

Pebbles of a coarsely crystalline, greyish-white, mottled limestone, collected by Prof. W. Boyd Dawkins from the conglomerates at Whitestrand, contain the following fossils: *Illænus Bowmanni*, var. *brevicapitatus*, *Primitia Maccoyi*, *Orthis calligramma*, *O. testudinaria*, *O. biforata*, *Rafinesquina deltoidea*, *Plectambonites quinquecostata*, *Atrypa expansa*, *Hyatella Portlockiana*, *Dayia pentagonalis*, *Platyceras verisimile*, *Stenopora fibrosa*, and crinoid stems. This assemblage of fossils corresponds strikingly with that of the Keisley Limestone; and it is therefore concluded that the pebbles have been derived from that rock. It seems hardly likely that they have come from so distant a locality as the Lake District; more probably there has been a local source, which would form a link between the limestone of Keisley and that of the Chair of Kildare.

CORRESPONDENCE.

THE *GEOLOGISCHES CENTRALBLATT.*

Sir,—Dr. Keilhack's invitation to authors to supply their own abstracts comes none too soon; it is to be hoped that this plan will prevent the mistakes which are apt to occur under the present régime. In the current number (March) two papers by myself on the Crystalline Limestones of Ceylon are reviewed. The abstract of the longer paper (p. 228) seems to show that the abstractor has no knowledge of crystalline rocks; otherwise he would not suppose that anyone could divide a *series of limestones* into gneisses, limestones, and granitites! Moreover, instead of reading the paper itself he has made use of the abstract printed by the Geological Society before the publication of the paper, and so actually credits the paper with containing a discussion of the origin of the limestones which in reality appeared elsewhere in a slightly modified form.

In the case of both references the author's name is incorrectly quoted. I should like also to take this opportunity of calling attention to the numerous misprints which occur in the pages of the *Centralblatt für Mineralogie*, etc.; see e.g. pp. 28, 29, 32, 60, 62 of the current year's issue.
A. K. Coomaraswamy.

Peradeniya, Ceylon, *March 23rd*, 1903.

PROFESSOR W. M. DAVIS AND RIVER CURVES.

Sir,—Professor Davis, in your issue for April, criticizes my little paper of October last, and offers an alternative theory. I laid down the rule that, "in the vast majority of cases, the affluents of rivers enter on the convex side of the curves." Mr. Davis admits the truth of this rule (p. 148), and therefore his criticisms and his theory must be consistent with it.

He cites cases where affluents form deltas at their mouths, and the main stream bends *away from* the tributary. Such exceptional examples were discussed by me, but it seems scarcely logical to quote them as hostile to a theory which only professes to explain cases where the rivers bend *towards* their affluents.

Professor Davis attributes to me a belief in "an initially straight main river." I did not assert, or even suggest, that such a thing ever existed. I merely assumed straight courses for short distances. We often get these even in oldish rivers, and they must have been incomparably more frequent in new ones. I suppose that a river has its tributaries even when it is young. If the shape of the ground has given rise to a bend towards an affluent at this stage, my theory is unnecessary. It is only required to account for the production of a bend when the course happens to be straight, which must often have been the case.

But Professor Davis offers a theory of his own. He explains my rule as due to the motion down the valley of the "meander system," so that, sooner or later, convex curves capture affluents entering on the concave. But this is only possible, as shown by his explanation and diagram (fig. 3, p. 147), where the meander system is in an advanced stage. The coming in of most tributaries on the convex curve has been determined much earlier. Professor Davis cannot deny this without denying the rule, which is based upon the study of rivers *in all stages* of development. His diagram (fig. 3) with its crowd of affluents entering on the concaves is not true to nature, or to the rule which he concedes to be true to nature. I fail, therefore, to see how the Professor's explanation can be "normal, effective, and fully verified."
C. Callaway.

Cheltenham, *April*, 1903.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. VI.—JUNE, 1903.

ORIGINAL ARTICLES.

I.—Cave Hunting in Cyprus.

By Henry Woodward, LL.D., F.R.S., F.G.S.

FROM the days when Nimrod began to be "a mighty hunter before the Lord," down to those in which our friend Fred. C. Selous shot 'big game' in Africa, the hunter has always occupied a specially exalted position and enjoyed a much envied notoriety in all countries. But alas for the wild animals! they are now rapidly becoming exterminated by man, and their place on the prairie, the pampa, the veldt, and in the forest will soon know them no more.

Early in the last century, that enthusiastic geologist Dean Buckland invented a new sport, devoid of slaughter or destruction of life, yet full of the keenest interest for the zoologist and the geologist, namely, the hunting for wild animals in cave deposits. The *later* poet of Kent's Cavern wrote :—

> " Full many a tooth with cutting edges keen
>   The virgin limestone caves of England bear ;
> Full many a bone of elephant, I ween,
>   Awaits the hunter who shall seek it there ! "

After labouring in Kirkdale, the Mendips, the Gower Caves, and those of Germany, France, and Gibraltar, Buckland published his "Reliquiæ Diluvianæ" in 1823. Out of more than thirteen caves he records the discovery of remains of Hyæna, Tiger (*Machærodus*?), Bear, Wolf, Elephant, Rhinoceros, Hippopotamus, Wild Boar, Horse, Deer, *Bos*, sp., Beaver, and other animals of less interest.

Even at that early date he excited at least one enthusiastic contemporary, the Rev. J. McEnery, who explored 'Kent's Hole,' Torquay, and proved the contemporaneity of early man with the Sabre-toothed Tiger (*Machærodus*) and other extinct animals in this ossiferous deposit. But public opinion had not as yet been aroused to take an interest in the question of 'the antiquity of Man,' and more than thirty years elapsed before further investigations were made, supported by Lyell, Busk, Schmerling, Falconer, Evans, Lubbock, Pengelly, Lartet, and Christy, and later on by Boyd Dawkins, Tiddeman, Hicks, Hughes, and others, down to the many workers of the present day.

After all that has been published upon the subject, one would have expected that such investigations would have lost their interest with geologists and naturalists, and also with the public at large, but this is far from being the case.

So lately as January last, Professor Boyd Dawkins communicated to the Geological Society of London an account of the discovery in 1901–2 of an ossiferous cavern of *Pliocene* age at Doves Holes, Buxton, Derbyshire, which, besides containing *Machærodus*, *Hyæna*, *Elephas*, *Rhinoceros*, *Equus*, and *Cervus*, yielded numerous examples of *Mastodon arvernensis*, an animal well known from the Crag, but no cave in Europe has hitherto yielded such a Pliocene fauna!

In September, 1898, the fresh skin of a species of *Mylodon*, a ground-sloth (named *Neomylodon Listai*), was discovered in a cavern near Consuelo Cove, Last Hope Inlet, Patagonia. Other numerous discoveries from the same cave followed, from which it appeared that many examples of this great sloth had been imprisoned and fed by man, and ultimately killed and eaten there by an early race of Indians, who also ate the horse, the huanaco (*Auchenia*), the bear, puma, and other animals, and left their remains, and also their own bones and weapons, to testify to their presence in the cave contemporary with the *Mylodon*.

The long series of researches in caves and ossiferous deposits on the islands and seaboard of the Mediterranean begun more than fifty years ago, and continued down to the present day, by numerous English and foreign geologists,[1] has resulted in the accumulation of most important evidence relative to the Eocene, Miocene, Pliocene, and Pleistocene faunas of this region, particularly those of Gibraltar, Concud in Spain, Mt. Léberon in France, Olivola and the Val d'Arno in Italy, the caves of Malta and Sicily, the deposits of Pikermi and Eubœa in Greece, Samos (Asia Minor), Maragha (Persia), the Fayum (Egypt). The important discoveries of vertebrate faunas in the Egyptian Tertiaries have already been noticed in the pages of this Magazine.[2]

Having made previous acquaintance with cave-hunting, by the exploration of a bone-cave on the River Wye and the description of its mammalian contents (see Geol. Mag., 1901, Dec. IV, Vol. VIII, pp. 101–106, with 8 text-figures), Miss Dorothy M. A. Bate set forth in the Spring of 1901 to make an exploration of the caves, said to be numerous, in the long limestone range of hills forming the northern border of the Island of Cyprus; she also found similar ossiferous deposits at Cape Pyla on the south-east coast.

Early in 1902 Miss Bate sent home to Dr. C. I. Forsyth Major some much worn teeth about the size of a pig's molars, which showed no indication of the trefoil pattern so characteristic of the molars of *Hippopotamus*. A second small parcel contained a few less worn teeth, together with a germ-tooth, from which it became at once evident that we had to do with a mammal of the Hippopotamus tribe, about half the size of a middle-sized *H. amphibius*, with molars exhibiting a modification of the common *Hippopotamus* pattern, approximating them to a less specialized type of Artiodactyle teeth. Dr. Forsyth Major's account of this discovery, from which we quote, was published in the Proceedings of the Zoological Society of London (June 3, 1902; pp. 107–112, plates ix and x) after the arrival of very numerous remains from Cyprus, obtained by Miss Dorothy Bate, and carefully developed in the British Museum (Natural History), Cromwell Road. In his description, the author compares the small *Hippopotamus* from Cyprus with the numerous remains of allied species preserved in the Museum from the other Mediterranean islands and from elsewhere. Dr. Forsyth Major had himself obtained and described a pigmy form from Madagascar (see Geol. Mag., 1902, Dec. IV, Vol. IX, pp. 193–199, Plate XII); another is found living in Liberia, west coast of Africa, at the present day, though probably verging on extinction. The large *H. amphibius* has still a wide distribution on the great lakes and rivers of Africa, and was once abundant also in Europe and in this country; whilst *H. sivalensis* is met with fossil in the Siwalik Hills of India. The Maltese caves and Sicily have yielded abundant remains of the small *Hippopotamus Pentlandi*, and of a much smaller and very rare species from Malta formerly called *H. minutus*, but now known as *H. melitensis*; this is about one-fifth larger than that from Cyprus, and the pattern of the teeth in the Maltese form differs from that of Cyprus and agrees closely, except in size, with the living *H. amphibius*; they cannot, therefore, be referred to the same species.

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[1] We recall the names of Professor Gaudry, Admiral Spratt, Dr. Falconer, Professor Busk, Dr. Leith Adams, Dr. C. I. Forsyth Major, Dr. Pohlig, Mr. J. H. Cooke, Dr. A. S. Woodward, and Dr. C. W. Andrews.

[2] Geol. Mag., 1899, p. 481, Fossil Mammalia from Egypt; 1900, p. 1, *Podocnemis Ægyptiaca*; p. 401, Fossil Mammalia from Egypt; 1901, pp. 400 and 436, Vertebrates of Egypt; 1902, p. 291, Extinct Vertebrates of Egypt; p. 433, Pliocene Vertebrate Fauna of Wadi-Natrun; 1903, p. 225, Evolution of Proboscidea.

Dr. Forsyth Major also compares the Cyprus *Hippopotamus* with one from the lignites of Casino (Tuscany), and also with one from the Wadi-Natrun, described by Dr. C. W. Andrews. They are larger in size than the Cypriote specimens and present other differences; the Casino specimen, in particular, being hexaprotodont in its dentition. Strange to say, a perfect counterpart both in shape and size to the Cyprus specimen is presented by Cuvier's "petit Hippopotame fossile" (*H. minutus*, Blainv.), a species of *Hippopotamus* which resembles in miniature the living hippopotamus, but which does not surpass the size of a pig, the locality of which was, alas! *unknown*, Cuvier having found the specimen in the basement of the Paris Museum without any label to record its origin. He afterwards received some identical remains from a private collection in Bordeaux, and from the Cabinet d'Histoire Naturelle of a M. Decken in Brussels. Whilst admitting the absolute identity of the Cyprus teeth collected by Miss Bate to-day with those described a hundred years ago (but *without a locality*) by Cuvier, Dr. Forsyth Major points out that in all stages of their growth they differ most specifically from the living *H. amphibius*. Cuvier's specimens certainly did not come from Dax, and Dr. Forsyth Major concludes (after careful comparison) that they may have been brought from Cyprus. It is very interesting, archæologically, to find that at the end of the seventeenth century the ossiferous breccias at Chrysostomo, near Kythræa (Hagia Marina), in the district of Nicosia, where Miss Bate obtained some of her collection, were looked upon as sacred relics which the Greek inhabitants worshipped, and that these very bones of the pigmy hippopotamus were passed off upon the pious as those of their saints! and were thus accidentally introduced to the attention of Cuvier and De Blainville a hundred years ago!

A still more interesting discovery has rewarded Miss Dorothy Bate's labours in the bone-caves of Cyprus, namely, the discovery of a new species of pigmy elephant in the same ossiferous deposits which contained the pigmy *Hippopotamus minutus*. But we will allow Miss Bate to tell the story in her own words.[1]

"While still in Cyprus the receipt of a grant from the Royal Society in April, 1902, enabled me to devote a considerable amount of time not only to making more extensive excavations in some of the caves previously found, but also to a search for further cave deposits. I confined my attention chiefly to the Keryina range of limestone hills in the north of the island, in the hope of finding bone caves containing other remains than those of the pigmy *Hippopotamus*, of which Dr. Forsyth Major has already given a short description[2] from specimens discovered by myself.

"In this search I was at length successful, although it was not until a certain amount of tentative digging had been carried on in four out of five newly discovered deposits that work was started on what appeared at first to be the most unpromising looking place which had been found, and was consequently the last to receive attention.

"However, during the first day one of the workmen found, not far from the surface, part of a tooth which was at once recognised as being that of an elephant. After this discovery every effort was made to procure a complete collection of the remains of this species, but at no time were either teeth or bones found to be so plentiful as those of *Hippopotamus minutus*, with which they were associated.

"Often not a single proboscidean tooth would be obtained during two or three days' work, and only eleven molars and parts of molars were procured as the result of three weeks' digging. It was then decided to continue excavations here for a short while longer, and this was done until the end of July, work being again resumed in the beginning of the following October.

"Altogether a good series was obtained of the teeth of this elephant, which is found to be a pigmy species. With the exception of the first milk molar (m.m. 2), specimens were procured of all the milk and permanent molars of both the upper and lower jaws; also a number of tusks of different sizes, though these included none of the tiny milk incisors. No teeth which could be referred to very aged individuals were obtained, for amongst the last true molars none have more than half their full number of plates in use.

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[1] "Preliminary Note on the Discovery of a Pigmy Elephant in the Pleistocene of Cyprus." By Dorothy M. A. Bate. Communicated by Henry Woodward, LL.D., F.R.S., F.G.S., V.P.Z.S., late Keeper of Geology, British Museum (Natural History). Read May 7, 1903. Proc. Roy. Soc., pp. 498–500.

[2] Proc. Zool. Soc., June 3, 1902.

"The series of teeth consisting of specimens of very small size, it was natural in the first instance to compare them with the remains of the dwarf species from the Pleistocene deposits of the caves and fissures of Malta and Sicily. It was thought probable that they would differ from these, the fact of the pigmy hippopotamus of Cyprus being distinct from those found in the other large Mediterranean islands lending colour to the supposition; this expectation was fulfilled, for the Cyprus fossils do not appear to be identical with any of the Maltese species, though they seem to come nearest to *Elephas melitensis* both in size and in the number of plates in the molars. The number of these plates in any particular tooth is liable to vary to a certain extent, but on taking the average, as far as this can be judged from the amount of material available, the resulting ridge formula, exclusive of talons, is

$$\div\ \frac{5}{5}\ \frac{7\text{–}8}{7\text{–}8}\ \frac{8}{8}\ \frac{9}{9}\ \frac{12}{12}$$

which practically agrees with that of *E. melitensis* given by Dr. Falconer.[1]

"The teeth of the Cypriote elephant are considerably smaller than those of *E. mnaidriensis*, from both Sicily and Malta, this being the largest species from the last-named island. They also differ somewhat in their ridge formula, which is that mentioned above, while Dr. Leith Adams[2] gives that of *E. mnaidriensis* as

$$\frac{3}{3}\ \frac{6}{6}\ \frac{8\text{–}9}{8\text{–}9}\ \frac{8\text{–}9}{8\text{–}9}\ \frac{10}{10}\ \frac{12\text{–}13}{12\text{–}13}$$

"The Cyprus form seems to have been also slightly inferior in size to *E. melitensis*, for its largest upper and lower molars do not equal, either in length or breadth, some of the specimens of the corresponding teeth of this Maltese species which are in the collection of the British Museum. Its tusks differ from all those from Malta in being compressed laterally, which character is especially noticeable in those of the female and young; further, they appear to be more strongly curved than those of *E. melitensis*.

"As a general feature it may be said that the molars from Cyprus are, on the whole, more simply constructed than those of *E. melitensis*. They show a still slighter tendency to 'crimping' in the bands of enamel, and are less inclined to develop the mesial expansion of the plates of dentine which is not uncommonly found in the teeth of *E. melitensis*, and is so conspicuous in those of *E. Africanus*.

"It is well known that when the plates of an elephant's tooth first come into use, the edging of enamel is in the form of a series of rings owing to the digitation of the plates. These are later worn into a single band surrounding the enclosed area of dentine.

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[1] Pal. Mem., vol. ii, p. 298; London, 1868.

[2] Zool. Soc. Trans., vol. ix (1874), p. 112.

"In the Maltese specimens it is not uncommon to find the encircling enamel persisting thus divided for a considerable time. Even four or five ridges may remain in this condition at one time in a single tooth, with perhaps an anteriorly decreasing number of rings. This is well shown in a tooth, now in the British Museum collection, doubtfully ascribed by Mr. Busk[1] to the first upper true molar of *E. Falconeri*. This is not so much the case in the Cyprus specimens, in which the bands of enamel only remain thus separated into several annuli for a very short while after the plate comes into wear.

"The molars vary considerably, some specimens having very broad crowns, while others are somewhat narrow. The bands of cement are wide, in perhaps the majority of cases almost, or quite, equalling in width the plates of dentine; this seems to be the exception and not the rule in the molars of *E. melitensis*.

"Taking into consideration the several characters in which the teeth of the Cyprus elephant differ from those of all the hitherto described dwarf species (putting on one side *E. lamarmoræ*[2] from the Pleistocene of Sardinia, the teeth of which are unknown to science) as well as the distinct habitat of the animal, I have come to the conclusion that it is specifically distinct from these other small forms, though possibly they were derived from a common ancestor, and I therefore propose to name it *Elephas cypriotes*.

"The discovery of the remains of this pigmy elephant, as well as of *Hippopotamus minutus*, in Cyprus, is interesting in comparison with the dwarf species from Malta and Sicily, and because the presence of an extinct mammalian fauna in this locality had not previously been recorded. The occurrence of these different, though apparently closely related, races of small elephants in widely separated islands of the Mediterranean, lends probability to the theory that this is a case of independent development along similar lines, the result of similar circumstances and environments. Nevertheless, it would perhaps be wise not to take it for granted, without further evidence, that this diminutive size is wholly and entirely due to specialisation." (Proc. Royal Society, May 7, 1903, pp. 498–500.)

Miss Dorothy Bate hopes to be able to communicate a more detailed account, with figures and full descriptions, of the collection of elephant remains from Cyprus. We also learn that she will shortly read a note upon a new species of extinct Genet from Cyprus at the Zoological Society of London.

It is to be hoped that this is but the commencement of a very successful scientific career for the author, who has evidently given her best energies to this most interesting and attractive line of investigation.

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[1] Zool. Soc. Trans., vol. vi, p. 295, pl. liii, fig. 9.

[2] Dr. Forsyth Major, "Die Tyrrhenis": *Kosmos*, vol. vii (1883), p. 7.

II.—A NEW CARBONIFEROUS ARACHNID.

By R. I. POCOCK, F.Z.S., of the British Museum (Natural History).

Introductory Remarks.

LAST April Dr. Anton Friĉ, of Prague, applied to the Natural History Museum for the loan of a fossil Arachnid which he had seen during a short visit to London in the Summer of 1902, and wished to include in a descriptive monograph of Carboniferous Arachnida which he has now in preparation. Since the specimen is unique, it was unfortunately impossible to accede to the request. Dr. Smith Woodward, however, kindly suggested that I should examine the specimen and, if necessary, describe and figure it, so that perchance an account of it might yet be in time to find a place in the monograph above referred to. The specimen, imbedded in the two pieces of a split nodule of clay-ironstone from the Carboniferous measures at Coseley, near Dudley, belonged formerly to the collection of Mr. Henry Johnson. It bears the register number 1551, and is ticketed by Dr. H. Woodward "*Eophrynus*, sp. nov." The dorsal surface is exposed, part of it adhering to one face of the matrix, part to the other.

1.—*Description of the Specimen; its generic and specific features.*

The *carapace* unfortunately is crushed, and nothing positive can be affirmed as to its structure save that it appears to have been slightly wider than long, with a shallow, postero-lateral constriction and a straight, transverse, posterior border. In the middle line behind, however, there is an acutely angular impression, obviously representing the median impression occupying the same position and presenting much the same form in *Eophrynus prestvicii*, H. Woodw.[1] The crushed condition of the carapace suggests that its median area was axially elevated as in the last-mentioned species and in *Kreischeria wiedei.*[2] Had it been flat or but slightly convex as in *Anthracomartus*, the details of its structure would have been preserved, if we may judge from the state of preservation of the relatively depressed abdominal area. It is justifiable, therefore, to conclude that the carapace was constructed essentially as in *Eophrynus* and *Kreischeria*, approaching in particular that of the former in the smallness of the posterior flattened area and the shortness of the median muscular impression. It was, however, less expanded at its postero-lateral angles, and occupied in this respect a stage of development midway between that presented by the carapaces of these two genera.

The *appendages* show no new morphological features. None of them are complete. Of the first and second pairs nothing is left but undecipherable fragments. On the right side three of the legs, which, from their position, I judge to be the first, second, and fourth, are fairly well preserved. The basal segments (coxa and trochanter) are very vaguely defined, but the femur, patella, tibia, and protarsus of the first and second pairs can be easily made out. They resemble those of *Eophrynus prestvicii* in being grooved, but are hardly noticeably pitted. In the fourth leg the femur, patella, and most of the tibia are shown.[1] On the left side part of the femur of the fourth projects from beneath the abdomen, and half the femur, the patella, and the greater part of the protarsus of the second are likewise visible.

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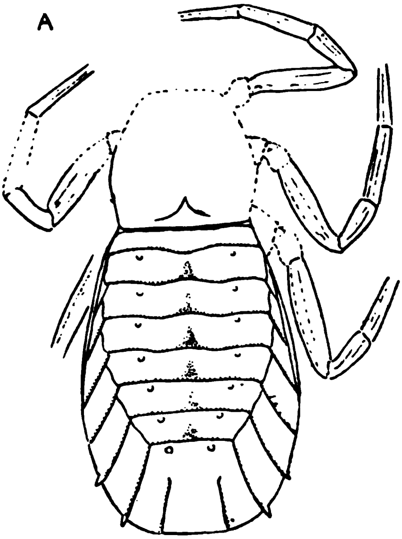
[1] See H. Woodward, GEOL. MAG., 1871, pp. 386–388, Pl. XI, and R. I. Pocock, GEOL. MAG., 1902, p. 490, Fig. 1, A.

[2] See Haase: Zeitschr. deutsch. geol. Ges., xlii (1890), pl. xxx, fig. 6.

A



B

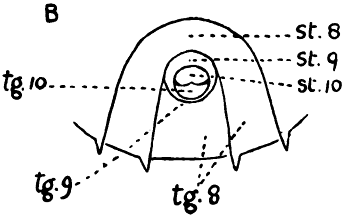


Fig. A.—*Anthracosiro woodwardi*, gen. et sp. nov. × about 2⅔. The lateral laminæ on the second, third, and fourth abdominal segments are relatively larger than seen in the specimen, and the angular projection of the tergal plates abutting against the antecedent laminæ a little too far back.

Fig. B.—Emended figure of the posterior extremity of the ventral area of *Eophrynus prestvicii*, showing the division of the anal tubercle into a tergal (*tg.* 10) and sternal (*st.* 10) element; *tg.* 9 and *st.* 9, tergal and sternal area of annuliform preanal somite; *st.* 8, sternal area of eighth somite; *tg.* 8, median and lateral lamina of the dorsal area of the same.

From the width of the carapace and the extent to which the basal segments of the appendages are left uncovered by its lateral borders, it may be inferred that the sternal area of the cephalothorax (prosoma) was wide, as in *Eophrynus*.

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[1] This appendage lies in a more vertical plane than the others, being thrust back partly over the abdomen. In the annexed figure what is to be seen of it has been drawn in a horizontal plane so that the structure of the abdomen is not concealed.

The *opisthosoma* (*abdomen*) shows very distinctly eight, and only eight, plates on its upper side. It thus resembles this region in *Kreischeria wiedei*, and differs from that of *Eophrynus prestvicii*, where nine plates are exposed, the first and second being short and apparently representing conjointly the first that is retained in *Kreischeria wiedei* and in the species now under notice. In the latter the first is the shortest of the series, the second the longest. The posterior border of the first is slightly convex in the middle; that of the others is fairly straight from side to side, although on account of a distinct and gradual elevation of the median area of the second, third, and fourth, this border appears from a superficial examination to be slightly concave in the middle. In the comparative straightness of the hinder border of the posterior terga, this species differs strikingly not only from *Eophrynus* and *Kreischeria*, but also from *Brachypyge* and *Anthracomartus*, in all of which the terga become progressively more and more recurved towards the posterior extremity of the abdomen. In the middle of the terga there is a distinct triangular granular area, wider behind than in front; there is also a series of fine granules defining the divisional lines between the terga and their laminæ; but the tubercles, which form so conspicuous a feature on the terga and lateral laminæ both of *Eophrynus* and *Kreischeria*, are here represented by a single pair of small tubercles upon the terga, and these are scarcely discernible on the anterior segments. The lateral borders of the third, fourth, fifth, and sixth terga are slightly produced anteriorly, and come into contact with the proximal extremity of the posterior side of the lamina of the antecedent segments. The lateral laminæ, too, are very different from those of the genera of Anthracomarti hitherto described. None are visible upon the first; on the second they appear as slender sclerites lying obliquely backwards; on the third and fourth they are of the same form, but larger, and project back in the same way, and their external margins are bordered by a strip of chitinous integument belonging to the lateral or ventral area of the body. It is not until the fifth segment is reached that the laminæ are at all comparable in development to those of other genera. From the fifth backwards they are large but fairly normal in size and form, their outer edges forming an evenly continuous curve. The posterior angles of the laminæ of the sixth and seventh segments, not of the seventh and eighth as in *Eophrynus* and *Kreischeria*, seem to be furnished with a spiniform process; but upon this point it would be rash to make a positive statement. The eighth segment is large, and furnished with the normal median and the two lateral laminæ separated by a deep groove; the lateral laminæ, however, are not marked off from the median area of the tergum, as is the case in most other Anthracomarti known. Owing to the small size of the anterior laminæ and the large size and obliquely backward direction of those at the posterior end of the abdomen, this region of the body is much longer in proportion to its width than in most Anthracomarti. The impression of the circular anal plate, omitted from the drawing, is plainly visible through the eighth segment, near its anterior border.

The principal measurements in millimetres of the type-specimen are as follows:—Total length 21, length of carapace 6, width 7 (approx.); length of abdomen 15; greatest width 10; width in front 6·5.

The characters enumerated above, though proving incontestably the right of the species to a place amongst the Anthracomarti near *Eophrynus* and *Kreischeria*, show no less clearly the impossibility of associating it with either of these genera. And since it is not intermediate between these or any two genera known, but differs strikingly from all in certain well-marked features, it becomes necessary to erect a new genus for its reception. This I propose to name and diagnose as follows:—

Gen. ANTHRACOSIRO, nov.

Carapace and appendages of *prosoma* constructed apparently as in *Eophrynus*, having the posterior horizontal area and the median impression short. *Opisthosoma* consisting of eight tergal plates on its upper surface, as in *Kreischeria*, but the anterior and posterior border of all the plates transverse and subparallel, and not becoming progressively more and more recurved towards the hinder end of the body, as in *Eophrynus*, *Kreischeria*, etc. All the lateral laminæ directed obliquely outwards and backwards: those of the anterior segments in the form of narrow sclerites, overlapped externally by the chitinised subjacent integument; those of the posterior segments large. In *Kreischeria* and *Eophrynus* all the laminæ are large and subsimilar in size and shape.

The generic name for this Arachnid is suggested by the geological formation in which the fossil was found, and by its affinity, remote though it be, to the existing Opilionid genus *Siro*.

The typical and only known species of this genus I propose to name *Anthracosiro woodwardi*, sp.n., dedicating it to Dr. Henry Woodward, F.R.S., as a slight tribute to his valuable contributions to our knowledge of fossil Arthropoda. The specific characters of this species are enumerated with sufficient detail in the description of the specimen already given.

2. *Further remarks upon the morphology of the Anthracomarti.*

While working out this new Arachnid, I examined a cast of *Eophrynus prestvicii*, which I did not see previous to the publication of the description of this fossil in the GEOLOGICAL MAGAZINE for October and November of last year. In this cast I notice one little structural point, of some morphological importance, which was not sufficiently defined in the others to allow me to speak with assurance about it. With reference to the anal plate, I said (p. 447): "This plate has the form of a transversely oval tubercle, and in one of the casts is marked by an incomplete transverse groove which suggests the possibility of its consisting of distinct sternal and tergal elements. If this be the case, the anal somite will resemble that of the Amblypygous Pedipalpi [Phrynidæ], rather than that of the Cyphophthalmous Opiliones." This groove is so strongly defined in the new cast that I see no escape from the conclusion that it represents the anal orifice. Hence the anal somite is complete with respect to its tergal and sternal elements. In *Eophrynus*, therefore, eleven terga and ten sterna can be made out in the opisthosoma. The first tergal plate, which has no sternal representative, I homologised with the tergum of the pregenital somite, and the second, with the corresponding first sternal plate, with the tergum and sternum of the genital somite in *Phrynus* or the Pseudoscorpiones. A subsequent study of the Opiliones, however, has suggested an alternative interpretation of these plates which divorces *Eophrynus* from the Pedipalpi and brings it more into touch with the members of the former order, with which the structure of the appendages of the prosoma and of the segments of the opisthosoma forcibly suggests the Anthracomarti to be nearly related. In *Kreischeria*, *Brachypyge*, and *Anthracomartus*, for instance, only ten terga and nine sterna seem to be distinguishable in the opisthosoma, the difference in the number of segments in this region between these genera and *Eophrynus* being attributable to the disappearance, either by fusion or excalation, of the first tergal and the last sternal plates that are traceable in the latter genus. And when it is remembered that ten terga and nine sterna are also found in the opisthosoma in the Cyphophthalmous Opiliones, that the tergum of the eighth forms the posterior extremity of the dorsal surface, and overlaps that of the ninth, which, with its corresponding sternum, is reduced to an annuliform preanal sclerite, and that the tenth or last tergal plate has no sternal equivalent, but closes like a valve over the anus and is encircled in the way just described, exactly as occurs apparently in *Anthracomartus* and *Brachypyge*, it is difficult to doubt that the segments of the opisthosoma correspond each to each in the Cyphophthalmi and the genera of Anthracomarti just mentioned. If this be so, the first tergum and the first sternum in *Anthracomartus*, *Kreischeria*, and *Brachypyge* will correspond to the tergum and sternum of the first post-genital somite in *Phrynus*. In that case the genital aperture in the Anthracomarti must have opened in front of the first sternum, as it does in the Opiliones, and not behind it as I assumed in my former paper. *Eophrynus* is peculiarly interesting in this connection because it appears to be the only known genus of Anthracomarti that has retained an unmistakeable trace of the genital somite, unless the suggestion that I made with regard to the first tergal plate in *Anthracomartus völkelianus* and *Kreischeria wiedei* be correct.

In view of this new reading of the facts, the explanation of Fig. 1, A, p. 490, of my previous paper may be emended as follows :—The plate marked *pregen. tg.* will be the tergum of the genital somite, and the plate marked 1 *tg.* (*gen.*) that of the first post-genital somite.

This view of the matter was briefly alluded to in my paper upon the classification of the Opiliones,[1] and coincides with the explanation of the morphology of *Leptopsalis*, one of the genera of Cyphophthalmi, put forward by Börner six months earlier.[2]

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[1] Ann. Mag. Nat. Hist. (7), x, pp. 504–515, December, 1902.

[2] Zool. Anz., June, 1902.

III.—The Purbeck Beds of the Vale of Wardour.

By A. J. Jukes-Browne, B.A., F.G.S.

THE paper written by the Rev. W. R. Andrews and myself, published in 1894, gave a more complete account of these beds than had previously been attempted; we showed that they were divisible into Lower, Middle, and Upper groups, comparable with those established by Professor E. Forbes in the Purbecks of Dorset, and characterized by the same species of Cyprides. This paper was based on the joint examination of exposures visible in 1890, though one of us, being then resident at Teffont, had observed and collected from these exposures for many years.

In the following year (1895) Mr. H. B. Woodward's memoir on the "Middle and Upper Oolitic Rocks" was published, and his account differed from ours in several particulars, notably as regards the thickness of beds referable to the three several divisions, as to the interpretation of the section near Dinton Station, and as to the total thickness of the formation. We refrained from comment at the time, partly because we were prepared to accept such corrections as were based on the freshly cut exposure near Dinton, and partly because the mapping of the district had not then been completed, and we were content to wait till this was done, in the expectation that Mr. Woodward would then reconsider some of the points on which we were not in agreement with him.

The mapping of the area was completed in 1900 by Mr. C. Reid, and this year (1903) the map (Sheet 298, new series), together with an explanatory memoir prepared by Mr. Reid, have been published. I am sorry to find, however, that the account of the Purbeck Beds in this explanation is merely a reprint of that given by Mr. Woodward in 1895, without any alteration, and with only some small additions by Mr. Reid. As the Geological Survey has failed to take advantage of this opportunity for revision, and as silence on our part might be understood as an admission that no such revision was necessary, I think it desirable to discuss some of the points in which our account differs from that given by Mr. Woodward. On some of these questions Mr. Andrews and I are disposed to modify the opinions expressed in 1894, but on others we continue to think that our views and observations are correct. We regret that it has not been possible for all concerned to meet on the ground, for we think that if this could have been arranged we should have come to an agreement on most, if not on all, the points of difference.

1. *The Section at Wockley.*—Mr. Woodward's account of this section is so different from ours that it is not easy to correlate the one with the other; but one point is clear, that he does not take the same plane of division between the Portland and Purbeck Series as we did. In this matter I am obliged to maintain that our account of the succession is not only fuller but more accurate than Mr. Woodward's, for he has not sufficiently distinguished between

the several beds at and near the junction of the two formations. That this is so will be apparent when the two descriptions are placed side by side (as below), but in order to indicate the correlative beds more clearly I have taken the details of the Portlandian part of the section from my notebook, in which the separation of the beds composing this series was fully noted.

Our account.	ft. in.	*Mr. Woodward's account.*	
6. Laminated brown and grey clay, with patches of black clay	0 4	Dark shaly clay, much squeezed up in places.	
5. Hard whitish chalky limestone with Cyprids, and a layer of cherty stone with small lenticles of flint at the top	1 3	Compact limestones, 2 feet.	
4. Soft grey and white laminated marl ...	0 6		
3. Hard flaggy limestone with black flints at the top, passing down into chalky and shelly limestone	2 3	Bed of Roach, with lenticular mass of chert at top.	10 to 15 feet.
2. Rubbly chalky limestone full of large Pectens, with marked planes at top and at base	1 0		
1. Chalky limestone with Portland fossils	13 0	Chalky limestones, obliquely bedded, with Portland fossils.	

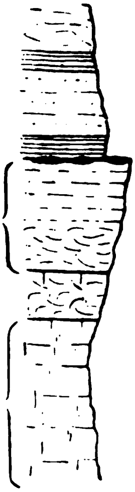
Bed No. 3 of the above succession is made up of two parts: the lower foot is a fairly compact, white chalky limestone, crowded with the shells of *Pecten lamellosus*; the upper part is a flaggy limestone without marine shells, but containing the Cyprides *Candona ansata* and *C. bononiensis*, which are marine and estuarine species: these two beds are closely welded together, they project beyond the others and usually break away in one block. Mr. Woodward follows Fitton and others (who considered the flaggy stone to be a fresh-water bed), and takes the plane along which they can be separated as the line of division between the Portland and Purbeck Series. We, having Professor Rupert Jones' assistance in determining the Cyprides, recognized the flaggy bed as of estuarine origin, and finding a marked plane at its summit, preferred to regard it as the topmost bed of the Portland Series.

I am quite prepared to admit that the beds which are welded together do contrast strongly in lithological character, and if this same kind of junction prevailed throughout the district, it would be a matter of small importance whether the one plane or the other were taken as the division between the two formations. It is well known, however, that in the Chilmark quarries (only two miles distant) there is a completely different development of beds at this horizon; at that place there are 16 feet of oolitic limestones between the top of the chalky limestone and the bed which is taken as the base of the Purbeck Series. I have suggested that the flaggy part of the 'junction bed' at Wockley is a reduced representative of these oolitic limestones, for if it is not so, then it is certain that these limestones can have nothing to represent them at Wockley, and in that case one would have expected to find a very well-marked plane of division between the Portland 'chalk' and the base of the Purbeck Beds.

Mr. Woodward rejects our view with the remark that, "to be consistent, however, we must continue to regard the old plane of division as the best, and going again to the district with Mr. Strahan no difficulty was found in determining this junction in the quarries near Tisbury and Chilmark." This strikes me as an extraordinary statement, for I cannot see where consistency comes in, and it is quite impossible to determine the same junction at Wockley and at Chilmark.

In all such cases where difference of opinion can arise, unless the main facts and features of the exposure are fully described, and unless the thickness of each separate bed is given, with a record of such fossils as come to hand, students who cannot visit the locality themselves are unable to form anything like a correct picture of the section. With this object we give in the Figure a diagrammatic representation of that portion of the quarry-face which includes the beds above mentioned.

SECTION AT WOCKLEY.



ft. in.	
	Base of confused beds.
0 4	Brown and dark grey clay.
1 3	Hard whitish limestone with Cyprides.
0 6	White laminated marl.
2 3	Hard flaggy limestone with black flints at top, *Candona*, etc., welded on to the top of Chalky limestone, full of the shells of *Pecten lamellosus*. Parting.
1 0	Rubbly chalky limestone, with *Pecten lamellosus*. Parting.
13 0	Chalk of usual type with fossils, but no flints.

2. *Division of Lower and Middle Purbecks.*—The best exposure of this junction is in the quarry at Teffont, and of this section a full account was given by Mr. Andrews and myself, for he had watched it for many years and had obtained many fossils from the different beds therein exposed. We found *Cypridea fasciculata* (var. of *granulosa*) abundant in the 'flagstone bed' and in the shale above that bed, while in the clay below it was less abundant and was associated with *C. purbeckensis.* This clay-bed may therefore be taken as the junction of the two groups, and it would not matter whether it were included in the one or the other. Mr. Woodward, however, includes the flagstone and some of the overlying beds in the Lower Purbeck, putting the plane of division at the base of the calcareous shale or shaly limestone, which is full of a small *Modiola.*

Mr. Woodward gives no reason for his grouping of the beds; he does not dispute our record of *C. fasciculata*, though he does not quote it, and here, therefore, the question of consistency certainly does arise, for the accepted divisions of the Purbeck Series are based on the successive appearance and prevalence of the three species of *Cypridea*, *C. purbeckensis*, *C. granulosa*, and *C. punctata*, and any writer who accepts this basis of classification should be consistent and should not group beds as Lower Purbeck when their prevalent Cyprid is *C. granulosa*.

If Mr. Woodward preferred to adopt some other criterion he might have explained his reason for abandoning that of the Cyprides; it may be only a coincidence that his Lower Purbecks include all the so-called 'Lias beds,' but it is conceivable that he preferred to group together beds of similar lithological character rather than be fettered by the range of a single small Crustacean. In that case, however, "to be consistent" he should have made a similar alteration in the grouping of the Lower and Middle Purbecks of Dorset; it is not satisfactory to have one method of classification for Dorset and another for Wiltshire.

I see no reason for any departure from Forbes' convenient method, and consequently I maintain that the Middle Purbeck group in the Vale of Wardour is much thicker than Mr. Woodward makes it. In his table on p. 267 he gives the thickness of Middle Purbeck Beds as only 12 feet, but he has apparently based this estimate on his section of the railway-cuttings west of Dinton given on p. 274. In this section he has referred the lowest beds exposed to the Lower Purbeck, but I believe he is quite mistaken in such a correlation. His 'brown sandy limestone' No. 1 represents the 'shaly limestone,' which he takes as the base of the Middle Purbeck in Teffont quarry, and the whitish limestones above are the equivalent of the 'White Bed' in that quarry. I write confidently of this because there are similar beds in the next cutting on the railway (south of Teffont), and their combined thickness there (4 feet) is rather more than the beds on the same horizon west of Dinton (where Mr. Woodward's measurement makes them 3 feet 9 inches).

With the above correction, Mr. Woodward's restricted Middle Purbeck would be about 15 feet thick, but when the group is carried down to the base of the shale below the 'flagstone' in the Teffont quarry, as I consider it ought to be, its total thickness is a little over 22 feet.[1]

3. *The Upper Purbeck Group.*—The existence of this group in the Vale of Wardour was denied until the publication of our paper in 1894, though the Dinton cutting, in which the lower part of the group is exposed, had been open for many years, and if anyone had taken the trouble to collect Cyprides from the beds and to submit them to an expert like Professor Rupert Jones, he would have

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[1] I admit an error in our computations of thickness on p. 66 of Quart. Journ. Geol. Soc., vol. L, due to our having counted in twice beds which we now recognize to be the same.

learnt that they contain plenty of *Cypridea punctata* without any *C. granulosa*.

In 1890 this cutting was partially grassed over, and the relations of the beds seen in it to those in the next cutting were not clear. The publication of our account induced Mr. Woodward to visit the place again, and he was fortunate enough to find that the cutting had been freshly widened so that the succession could be clearly seen; further, by digging below the level of the rails, he carried his measurements down to the *Archæoniscus* bed. Some of these beds were admitted by Mr. Woodward to be of Upper Purbeck age, but the greater part of what we had regarded as Upper Purbeck was referred by him to the Wealden.

With respect to the beds seen in the cutting, I accept the fresh evidence obtained by him: I agree with him as to the plane of division between the Middle and Upper Purbeck groups, and admit that there is no necessity for the hypothetical faults which we had introduced. I have no reason to doubt his measurements of the beds in the middle of the anticline, but think that the sand and clay at the base of the Upper Purbecks must thicken to the westward. Some of the sand which I saw at the eastern end of the second cutting may have been rearranged, but I do not think there was less than 6 feet of it *in sitû*, or less than 4 feet of the clay below. This view is confirmed by the section in the deep cutting south of Teffont (not described by Mr. Woodward); we gave a complete account of the beds therein exposed, and it is now quite clear that they include the base of the Upper Purbeck. The highest beds seen are as follows:—

	ft.	in.
Wet grey and yellow sand	3 or 4	0
Light-grey sticky clay	1	8
Soft marly clays with thin brown iron-stained layers ...	2	0
Light buff-coloured marl	0	4
Hard whitish grey-hearted silty limestone	1	0

The limestone is clearly the same as that taken at the top of the Middle Purbeck in the Dinton cutting, and there is here 4 feet of marl and clay above it, succeeded by more than that thickness of sand. Mr. Andrews and I also saw the same limestone in the next cutting (south-east of Chicksgrove Farm), overlain by grey and yellow clay, brown sand and sandstone, and a gravelly soil, but these upper beds were confused by slipping; they are clearly a remnant of the outlier of Upper Purbeck subsequently mapped by Mr. Reid north-west of the Farm.

The basal part of the Upper Purbeck group being now established, there remains the question of its upper limit, and this we admit to be difficult of settlement. Mr. Woodward draws the line between Purbeck and Wealden, quite arbitrarily, at a thin layer of sand seen in the cutting about 10 feet below the surface of the ground. Of the beds thus referred to the Wealden Mr. Reid remarks, "In the Dinton cutting only some ten feet of the lower part of the Wealden Beds can be examined, and the exact age of these deposits is perhaps not quite satisfactorily made out." He thus admits that their age is a matter of opinion, and I can understand that as he and Mr. Woodward were obliged to draw a line somewhere for delineation on the map of the Geological Survey they gave the Wealden the benefit of the doubt.

Mr. Andrews and I considered these beds as a continuation of the Upper Purbeck, and we obtained fossils from the material thrown out of a well sunk at the cottages near Dinton Station; it is true that most of the species found range from Purbeck to Wealden, but they included *Cypridea punctata*, which has not yet been recorded from Wealden. The well is 40 feet deep, and the fossils probably came from less than 30 feet down. How much of this thickness is Purbeck and how much Wealden is evidently a matter of opinion and extremely uncertain. The following may be given as a summary of the beds which lie between the Lower Greensand and the Middle Purbeck, near Dinton, with estimated thicknesses:—

	feet.
4. Yellow and grey silty clays by Dallwood Farm ...	15–20
3. Grey silty marl (in the well)	10–12
2. Stiff grey and yellow clays (in the well and cutting)...	25
1. Marls, shales, and grits (in the cutting)	12

No. 1 is Upper Purbeck; No. 2 may be either Purbeck or Wealden; Nos. 3 and 4 are probably Wealden.

4. *Purbeck and Wealden at Teffont.*—When in 1890 Mr. Andrews and I endeavoured to trace the Upper Purbeck and Wealden clays towards Teffont we found that their thickness became very much less, and that the space occupied by their outcrop north of Teffont Rectory was very narrow. We found there exposures of the following beds in descending order:—

D. Black clay.
C. Greenish-black glauconitic sand.
B. Mottled clay, white, yellow, and claret-coloured, like the 'cat's-brain' clay of Kentish Wealden.
A. Yellow silty clays.

The upper two members of this succession we regarded as Lower Greensand (Vectian), the lower two as Wealden, believing A to be part of the Dallwood Farm beds, No. 4 of the series near Dinton. We saw nothing between this and the Middle Purbecks, and there did not seem room for the Upper Purbecks (Nos. 1 and 2) to come in, so that we concluded the Wealden had here overlapped the Upper Purbeck Beds.

From the newly issued 1 inch map I find that Mr. Reid does not carry the Wealden clays so far west as the point where we saw the above succession, but has coloured all the beds north of the Rectory between the Middle Purbeck and the Vectian Sands as Upper Purbeck. It is clear, therefore, that Mr. Reid agrees with us in thinking there is not room enough here for the whole thickness of Upper Purbeck and Wealden, but differs from us in regarding the beds which do occur as Purbeck instead of Wealden. In the explanation of the map (Sheet 298) he does not describe any exposure of these beds north of Teffont, either under the head of Purbeck or Wealden, but quotes our description of them in his chapter on the Lower Greensand, and then remarks that he doubts our correlation of the clays at Dinton and Teffont.

Here, again, therefore, it is a matter of opinion, and those responsible for the published mapping of this bit of ground do not seem able to give very good reasons for their beliefs. We suppose Mr. Reid correlates the yellow silty clay of Teffont with the yellow grey and white clays at the top of the Dinton cutting, but in the latter place there is nothing like the peculiar 'cat's-brain' clay, and until some one can find that kind of clay in the Upper Purbeck of the Vale of Wardour I shall continue to regard it as belonging to the Wealden, and to believe that Mr. Reid has not carried the Wealden far enough to the westward along the northern side of the Vale.

When describing the Purbeck Beds in 1894 we incidentally remarked that there was a complete discordance between the Purbeck Beds and the Lower Cretaceous Series, "including the Wealden." This was carelessly expressed: the great unconformity is undoubtedly at the base of the Lower Greensand, but we certainly did think that the Wealden overlapped the Upper Purbeck. Whether it really does so depends on the correct separation of the Wealden from the Purbeck. The bare idea of a break at the base of the Wealden fluttered the dovecotes of Jermyn Street to such an extent that the question seems to have assumed proportions of paramount importance in the minds of Messrs. Woodward and Reid. Others, however, may deem it of equal importance that the divisions of the Purbeck Series should be established on logical grounds, that the thickness of each group should be carefully estimated, and that the outcrop of the Wealden Beds should be carefully discriminated from that of the Upper Purbecks.

Finally, Mr. Reid's reference to *Endogenites erosa* adds nothing to the strength of his position. He admits that "it is too doubtful a form to be of much value for correlation," but immediately adds, "though its presence supports the view that the strata containing it truly belong to the Wealden period, and are not, as supposed by Messrs. Jukes-Browne and Andrews, of Purbeck age." He quite ignores the fact that we found a large piece of similar endogenous wood in the Upper Purbeck sand of the Dinton cutting. It is also a fact that pieces of *Endogenites erosa* have been found close to the spots where outliers of the Upper Purbeck are shown on the map, and when it is remembered that the fossil wood has never been found in the beds referred by Messrs. Woodward and Reid to the Wealden, it will be apparent that the facts are much more in accord with our view than with Mr. Reid's.

In conclusion, I may place on record that I have submitted one of the surface fragments to Mr. A. C. Seward, and he kindly informs me that he believes it to be the true *Endogenites erosa*, now known as *Tempskya Schimperi*, and in reality the stem of a tree-fern. Unfortunately, I could not send him a piece of the wood found in the sand at Dinton, and cannot therefore affirm that it was also *Tempskya*, but it was so similar that I took it to be the same.

I append a revised estimate of the total thickness of the Purbeck Beds in the Vale of Wardour, if the Upper group is to be restricted within the limits indicated by Mr. Woodward.

	ft.	in.	
Mean thickness from top of No. 30 to base of limestone with *Unio* (part of 21)	12	0	Upper Purbeck, 22 feet.
Yellow sands with *Endogenites*	6	0	
Grey clays and marl	4	0	
Thickness from top of No. 19 to top of the *Archæoniscus* bed (No. 13)	7	0	Middle Purbeck, 22¼ feet.
From top of No. 19 to top of cinder bed (south of Teffont)	4	3	
From top of cinder bed to base of the 'scale' below the flagstone at Teffont	11	0	
From base of 'scale' to marl-band below the 5th Lias	15	9	Lower Purbeck, 64½ feet.
Section in Ridge quarry from marl below 'Lias' to bottom of quarry	19	10	
Allowance for gap between quarries	7	0	
Section at Wockley from surface to base of Purbeck Beds	22	0	
Total	108	10	

IV.—The Disappearance of Limestones in High Teesdale.[1]

By C. T. Clough, M.A., F.G.S., of H.M. Geol. Survey.

In High Teesdale, on certain hillsides, the structure of which is in most respects clear, the observer is struck by the disappearance of some, generally constant, limestone which ought naturally to occur. The limestone most usually missing is the Great Limestone, which, with the exception of the Melmerby Scar Limestone, is the thickest of all in the dale. Though the ground is almost free from peat and drift, and plainly shows the banks formed by the Four Fathom Limestone and Firestone,[2] there is yet perhaps neither bank nor 'shake-hole' (swallow-hole) to represent the Great Limestone. In the cases referred to the difficulty cannot be accounted for by supposing that the limestone along its outcrop is thrown out by a fault, for the outcrops of the beds above and below can be followed round the hill without interruption.

Where the limestone disappears many masses of sandstone are usually found, most of which seem somewhat disturbed; and, in the small streams, thin irregular bands of soft, rather siliceous, clay and iron ochre occur. The clay and ochre represent the limestone, which, in the language of the dalesmen, has been 'eaten away' along the outcrop and replaced by 'famp.'

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[1] The substance of this communication was written 25 years ago. Since then Mr. F. Rutley has written "On the Dwindling and Disappearance of Limestones" (Q.J.G.S., 1893, vol. xlix, p. 372), but he makes no mention of their special liability to dwindle in the neighbourhood of faults and veins, and gives no instances of their disappearance on a large scale. Mr. J. R. Dakyns has written a short paper "On 'Flots'" (Report Brit. Assoc., 1881, p. 634), and the material in many 'flots' seems of much the same nature as 'famp.' The writer has recently seen an instance of famping, differing somewhat from the examples in Teesdale, in one of the limestones (the Skateraw Middle Limestone), which has been quarried at Catcraig, near Dunbar, and this has recalled the subject to him.

[2] The Four Fathom Limestone is a little below the Great, and the Firestone is a sandstone a little above the Great Limestone.

The best locality for observing 'famp' and the accompanying phenomena is at the Highfield 'hushes,'[1] above Grasshill. It is there seen in clear section that the Great Limestone, the average thickness of which in the neighbourhood is 55 feet, is replaced by 10 or 12 feet of soft siliceous, irregularly banded, ochreous clay. Several veins cross the hushes, and near these veins low rambling levels have been driven in search of lead ore. Such work gives rather uncertain returns, for there are no straight or constant strings of ore to follow, but every here and there nodular masses of ore, occasionally a foot or more in breadth, are met with, which seem on the whole to repay the miners. These masses often occur together in groups, the centre of the larger examples being composed of galena, and the outside usually of carbonate of lead, or of a mixture of carbonate, phosphate, and arseniate. In the smaller, those with a breadth of an inch or less, the mass is often composed throughout of the three last-mentioned ores without any galena. The outlines of most of the lumps are rounded, and they show no sharply defined crystals of galena like those common in the ordinary veins. The miners think that the famp-ore has been water-worn, and they are probably right in one sense, though the carbonate and phosphate of lead, etc., on the outsides of the lumps, are often in well-formed crystals which cannot have undergone rolling.

A few other minerals, associated with the lead ores in the adjacent veins, are also found in the famp. Besides these, there are hard round lumps, each consisting of a limestone centre and an outer coat, which shows a gradual passage between limestone and famp. No sandstone boulders have ever been noticed in famp.

It is usually stated that limestones are not so much famped 'under the hill' as at the outcrops, and the sections at the head of Highfield hushes seem to confirm this opinion. In the gutter made in 1876 to hush part of the famp, a series of small faults and local contortions were seen, which bring down the 'Coal Sills,' the sandstones next above the Great Limestone, to lower levels towards the south, the direction in which the outcrop of limestone should occur. We know that these disturbances do not affect the beds below the famp, for they were not met with in the Cowby level, which is driven nearly under this gutter. They seem due to the dwindling away of the limestone as it comes near the surface. Famp probably replaces the Great Limestone in Yad Moss level, South Lang Tae sike, Blackway Hole hushes, the West Beck and Old Langdon hushes, and Pikelaw hushes. It probably also occurs for most of the way between Blackway Hole and South Lang Tae sike, a distance measured along the outcrop of about a mile, from the Yad Moss level to some distance on the north side of Crook Burn, and for half a mile or more on the north side of Henrake hush.

The areas wherein limestone has been replaced by famp are sometimes sharply defined. In Pikelaw hushes, vertical walls of limestone, 20 or 30 feet high, stand (1876) close against sandstone and shale, but when the margins of the limestone are examined by hushing, .etc., they show no vein, and they do not continue in nearly straight lines as most veins do. Parts of the limestone stand up like ruined towers on the floor of Blackway Hole hush, and it is said they remain much as they were when originally found sticking up in a mass of famp.

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[1] A hush is an artificial wash-out, made for the purpose of baring and cutting the strata and the veins which cross them. In the process of hushing a reservoir is made high on the hill, and the water is let out in a flood along the desired direction.

The famp in the Yad Moss level is mixed with irregular streaks of a black earthy mineral, part of which is probably a black ore of manganese. In the West Beck and Old Langdon hushes the famp consists of nearly pure iron ochre, and it would no doubt have been used for smelting if it had been in a more accessible locality. In Weardale a famp of similar character has long been largely worked for this purpose. The light yellow varieties of famp are sometimes used instead of whitewash, for painting over walls, etc.

The limestones in Teesdale, which, next after the Great Limestone, are most conspicuously famped, belong to the Melmerby Scar group of limestones, in the neighbourhood of Silver Band Mine, Cronkley Fell. These limestones and the Great are generally rather pure limestones (the Great usually contains about 95 per cent. of carbonate of lime), so that the famp cannot be solely the residue of their decomposition. The greater part of it must have been introduced from without. It is most abundant where veins of ore are most numerous, and it is probable that most of the famp material was introduced by the same agent which filled so many of the neighbouring veins with ironstone and other minerals.

Where an ironstone vein passes through limestone, the width of the vein is nearly always greater than in sandstone or shale, for the limestone 'cheeks' are converted into ironstone for a certain breadth at the sides of the vein. The ironstone has not only grown in the open fissure of the vein or fault, but has also replaced part of the limestone. This is shown by the casts of corals, crinoids, etc., which are found in the ironstone. In a similar way, also, where a quartz vein passes through limestone, the limestone on the sides is partly replaced by finely crystallized quartz.

We suppose that the fissures made in the course of earth movements formed channels for the circulation of water holding various minerals in solution, and that this water not only deposited minerals in the fissures, but also gradually dissolved part of the limestone it passed through, and deposited other minerals in its place. The replacement effected along the sides of the veins varies greatly in extent, and it is probable that a replacement by carbonate of iron was the first stage in the manufacture of famp.

But why is the limestone more often dissolved away along the outcrop than elsewhere? It appears as if the action, which was first started by water circulating along the veins, had been continued and modified in recent times, since the present surface of the ground was developed, and that this later action is perhaps still in progress.

It is obvious that where a limestone was already partly dissolved away near the outcrop, the ground above would be affected by local faults and slips, and would be specially liable to penetration by surface-water, which, already charged with carbonic acid, would therefore be well suited for dissolving more of the limestone. The same surface-water which dissolved the additional portion of limestone, may also have altered the character of the substances which were first formed near, or in place of, limestone, partly mechanically, by rearranging them, and partly chemically, by converting the carbonate of iron into the hydrated peroxide,[1] and galena into other salts of lead. It would, of course, take longer to completely change the larger masses of galena than the smaller, and hence in the larger a centre of unchanged galena still often remains.

It may be noted, in conclusion, that these instances of solution of limestone on a large scale show one method by which the higher beds in a series may be faulted and folded while the lower beds remain undisturbed.

V.—THE PALÆONTOLOGICAL AND GEOLOGICAL COLLECTIONS OF THE BOHEMIAN MUSEUM IN PRAGUE.

By Dr. ANT. FRITSCH.

(PLATE XIV.)

AFTER transferring the collections to the new building in the year 1892, more than ten years work was necessary to finish the arrangement of 251 cases, which occupy seven large rooms. Now nearly all this labour is completed, and those who are interested in palæontology will be glad to learn some details as to the general arrangement of the Museum.

All fossils are fixed on tablets, or placed in glass-topped boxes. The labels are printed on greenish paper, and contain references to the work and plates where the type-specimens are described and figured. Beneath very small fossils is fixed a magnified figure taken from the book[2] where the species has been published. The under side of the tablets is used for white labels with further (written) details, catalogue numbers, etc. The inclination of the cases is 45° or 60°. Six rooms are devoted to the geology and palæontology of Bohemia and one large room to the general stratigraphical collection.

The first room, called "Barrandeum" (26 metres long), contains the famous collection of Barrande, in which are incorporated the old Museum collection, the collections of Bishop Zeidler, of Corda and Hawle, and of Professor Novák. In six wall-cases are exhibited representative specimens of the chief Azoic, or Eozoic, Primary and pre-Cambrian rocks of Bohemia, on which the younger formations are deposited. Sixty glazed cases contain the Cambrian, Silurian, and Devonian fossils, arranged in stratigraphical order. In the drawers beneath, the specimens are arranged in zoological order in

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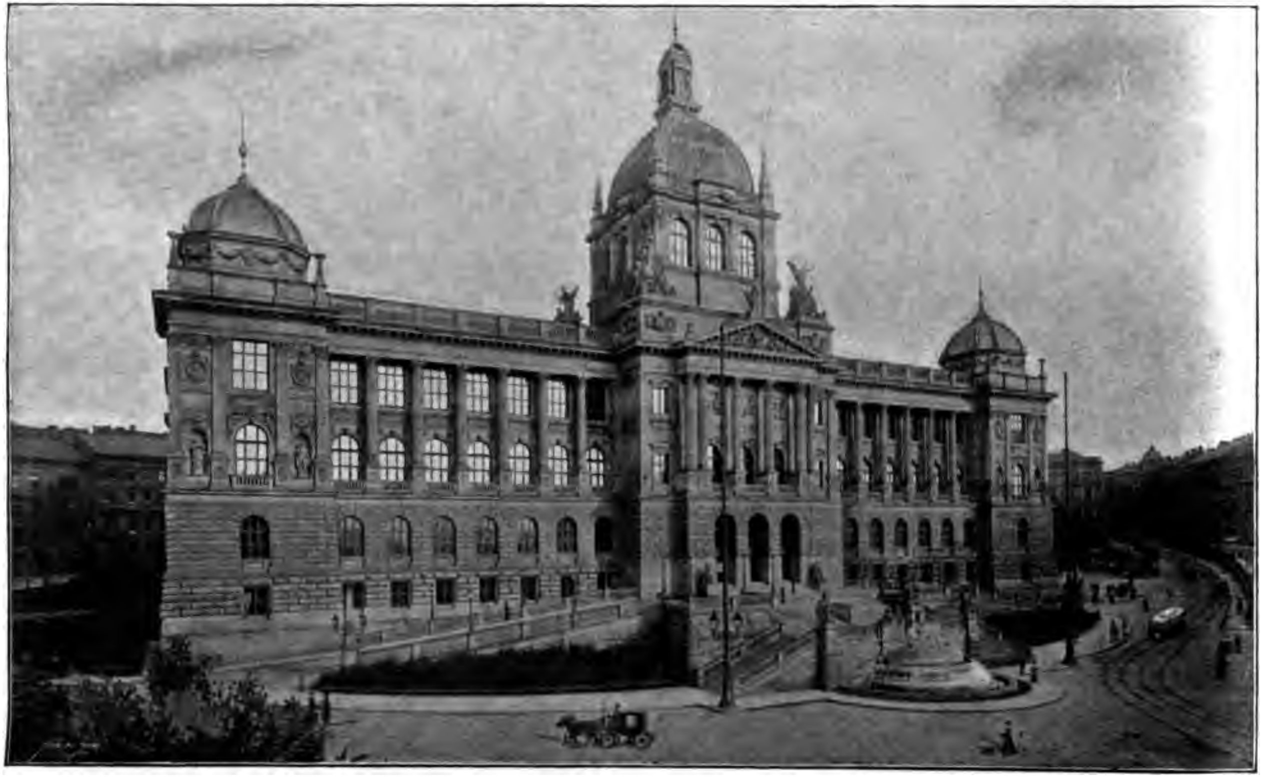
[1] See Professor J. W. Judd, "Geology of Rutland" (Mem. Geol. Surv.), p. 135.

[2] See my article in *Natural Science*, vol. viii (1896), No. 49.



THE ROYAL BOHEMIAN MUSEUM, PRAGUE.

such a way that every type-specimen of Barrande's can be quickly and readily referred to. Each case exhibits in its upper part about 100 objects, and beneath each are 18 drawers (in three rows) of specimens for purposes of scientific study. A special case is devoted to the memory of J. Barrande, showing a copy of his monumental work (28 vols. 4to, containing 1,454 plates, giving illustrations of more than 4,800 species from the Bohemian Palæozoic Basin); then a photograph of the memorial tablet fixed on the Silurian rocks near Kuchelbad, and a photograph of the house in which he resided in Prague during 40 years, together with the tools he used in developing his fossils, and his portrait when he first arrived in Bohemia.

The second room, called "Sternbergeum," about 100 square metres, contains the type-specimens of the work of Count Caspar Sternberg, "Flora der Vorwelt." In a central pavilion are grouped about 40 large and striking examples of Carboniferous plants, forming a pyramid, on the summit of which is placed a bust of Sternberg in Carrara marble. In two of the wall-cases are placed the Arachnida and Scorpions of the Coal-measures, 25 species represented by about 60 specimens.

The third room is a laboratory of phytopalæontology.

The fourth room, 100 square metres, contains the stratigraphical collection of the Bohemian Coal-measures, with type-specimens of Feistmantel's works. Then follows the Permian formation, with the type-specimens of the work "Fauna der Gaskohle" by the writer. The last of the 28 cases shows a rare collection obtained from the Jurassic beds in northern Bohemia, being the type-specimens of Dr. Bruder's work.

The fifth room, of equal proportions, contains the Chalk formation of Bohemia, displayed in 28 cases. Three cases contain a splendid exhibition of the Cenomanian flora described by MM. Velenovsky and E. Bayer. The marine fossils from different stages (Cenomanian-Senonian) are here shown as documents in evidence of the monographs published by myself in the "Archiv für Landesdurchforschung Böhmens," exhibited in 25 cases.

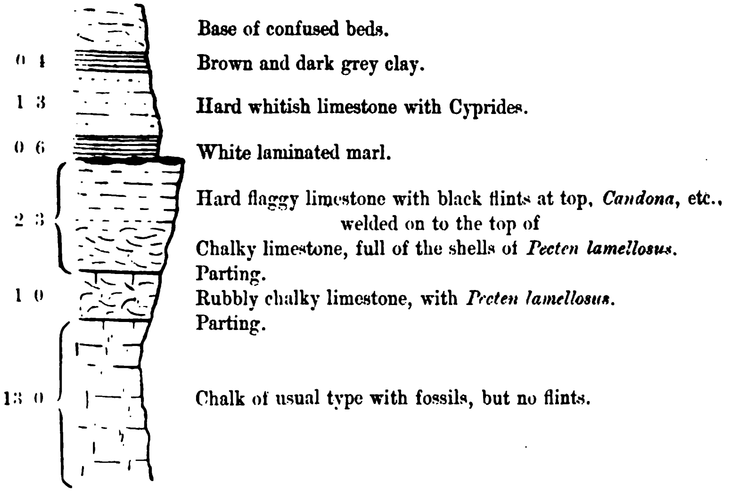
The sixth room is devoted to the Tertiary (lacustrine) formation of Bohemia, and shows in 28 cases a rich flora and fauna (fishes, insects, mollusca, and a great part of the skeleton of *Dinotherium* found near Abtsdorf, and many other mammalian remains).

The last room of the series, devoted to Bohemian geology and palæontology, contains in 12 cases the diluvial and alluvial fauna, the vertebrates described by Kafka, and the mollusca by Babor. There are also exhibited specimens to illustrate the lithological character of each period. In a central pavilion are displayed the remains of *Elephas*, *Rhinoceros*, *Cervus*, *Bos*, etc. Near the window is exhibited a complete skeleton of the Rhinoceros found near Pardubic.

In all the rooms named above are also displayed geological maps showing the geographical distribution of the formations in Bohemia, and diagrammatic coloured sections of the principal localities, Mr. Woodward rejects our view with the remark that, "to be consistent, however, we must continue to regard the old plane of division as the best, and going again to the district with Mr. Strahan no difficulty was found in determining this junction in the quarries near Tisbury and Chilmark." This strikes me as an extraordinary statement, for I cannot see where consistency comes in, and it is quite impossible to determine the same junction at Wockley and at Chilmark.

In all such cases where difference of opinion can arise, unless the main facts and features of the exposure are fully described, and unless the thickness of each separate bed is given, with a record of such fossils as come to hand, students who cannot visit the locality themselves are unable to form anything like a correct picture of the section. With this object we give in the Figure a diagrammatic representation of that portion of the quarry-face which includes the beds above mentioned.

SECTION AT WOCKLEY.


ft. in.
0 4
1 3
0 6
2 3
1 0
13 0
Base of confused beds.
Brown and dark grey clay.
Hard whitish limestone with Cyprides.
White laminated marl.
Hard flaggy limestone with black flints at top, *Candona*, etc., welded on to the top of
Chalky limestone, full of the shells of *Pecten lamellosus*.
Parting.
Rubbly chalky limestone, with *Pecten lamellosus*.
Parting.
Chalk of usual type with fossils, but no flints.

2. *Division of Lower and Middle Purbecks.*—The best exposure of this junction is in the quarry at Teffont, and of this section a full account was given by Mr. Andrews and myself, for he had watched it for many years and had obtained many fossils from the different beds therein exposed. We found *Cypridea fasciculata* (var. of *granulosa*) abundant in the 'flagstone bed' and in the shale above that bed, while in the clay below it was less abundant and was associated with *C. purbeckensis*. This clay-bed may therefore be taken as the junction of the two groups, and it would not matter whether it were included in the one or the other. Mr. Woodward, however, includes the flagstone and some of the overlying beds in the Lower Purbeck, putting the plane of division at the base of the calcareous shale or shaly limestone, which is full of a small ***Modiola***.

Mr. Woodward gives no reason for his grouping of the beds; he does not dispute our record of *C. fasciculata*, though he does not quote it, and here, therefore, the question of consistency certainly does arise, for the accepted divisions of the Purbeck Series are based on the successive appearance and prevalence of the three species of *Cypridea*, *C. purbeckensis*, *C. granulosa*, and *C. punctata*, and any writer who accepts this basis of classification should be consistent and should not group beds as Lower Purbeck when their prevalent Cyprid is *C. granulosa*.

If Mr. Woodward preferred to adopt some other criterion he might have explained his reason for abandoning that of the Cyprides; it may be only a coincidence that his Lower Purbecks include all the so-called 'Lias beds,' but it is conceivable that he preferred to group together beds of similar lithological character rather than be fettered by the range of a single small Crustacean. In that case, however, "to be consistent" he should have made a similar alteration in the grouping of the Lower and Middle Purbecks of Dorset; it is not satisfactory to have one method of classification for Dorset and another for Wiltshire.

I see no reason for any departure from Forbes' convenient method, and consequently I maintain that the Middle Purbeck group in the Vale of Wardour is much thicker than Mr. Woodward makes it. In his table on p. 267 he gives the thickness of Middle Purbeck Beds as only 12 feet, but he has apparently based this estimate on his section of the railway-cuttings west of Dinton given on p. 274. In this section he has referred the lowest beds exposed to the Lower Purbeck, but I believe he is quite mistaken in such a correlation. His 'brown sandy limestone' No. 1 represents the 'shaly limestone,' which he takes as the base of the Middle Purbeck in Teffont quarry, and the whitish limestones above are the equivalent of the 'White Bed' in that quarry. I write confidently of this because there are similar beds in the next cutting on the railway (south of Teffont), and their combined thickness there (4 feet) is rather more than the beds on the same horizon west of Dinton (where Mr. Woodward's measurement makes them 3 feet 9 inches).

With the above correction, Mr. Woodward's restricted Middle Purbeck would be about 15 feet thick, but when the group is carried down to the base of the shale below the 'flagstone' in the Teffont quarry, as I consider it ought to be, its total thickness is a little over 22 feet.[1]

3. *The Upper Purbeck Group.*—The existence of this group in the Vale of Wardour was denied until the publication of our paper in 1894, though the Dinton cutting, in which the lower part of the group is exposed, had been open for many years, and if anyone had taken the trouble to collect Cyprides from the beds and to submit them to an expert like Professor Rupert Jones, he would have

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[1] I admit an error in our computations of thickness on p. 66 of Quart. Journ. Geol. Soc., vol. L, due to our having counted in twice beds which we now recognize to be the same.

that only those cubic crystals which display birefringence exhibit divergence from the theoretical angles, but Brauns showed that in lead nitrate, ammonia-alum, and spinel, for both isotropic and birefringent crystals alike, the octahedron angle may differ by as much as 20′ from that of the regular octahedron.

The author has endeavoured to trace the changes of angle upon one and the same crystal during its growth by measuring it at intervals without moving it from the solution in which it is growing. This is accomplished by means of a new telescope-goniometer in which the crystal is observed through one side of a rectangular glass trough, and the changes in the inclination of each face are followed by watching the displacements of the image of a collimator slit viewed by reflection in it. The crystal is held by a platinum clip which it envelops as it grows. Small movements of the image are followed by means of a special micrometer-eyepiece which accurately measures the magnitude and direction of the displacement.

Examined in this way an octahedron of alum (ammonium or potassium) is found to yield, not one, but three images from each face; and closer inspection shows that the crystal is not really an octahedron, but has the form of a very flat triakis-octahedron. It often happens that of the three faces which nearly coincide, one is large and the remaining two very small, so that of the three images one is bright and the others are very faint and can only be discerned with difficulty; in such a case the crystal as measured in the ordinary way would appear to be an octahedron whose angle differs from the theoretical value by a few minutes.

When a growing crystal of alum is watched for several hours or days, it is found that the three images yielded by an apparent octahedron face continually change their position; one set fades away and is replaced by another set which are generally more widely separated than those which they succeed. The images move in three directions inclined at 120° to each other, and indicate that these faces always belong to a triakis-octahedron. The point in which the lines of movement intersect within the field of view of the telescope would, therefore, be the position of the image reflected from the true octahedron face. Measured in this way the octahedron angle of alum is found to be the theoretical angle 70° 31¾′.

The images do not move continuously, but *per saltum*, indicating that the reflecting planes are vicinal faces which probably possess rational indices, and must therefore be inclined at certain definite angles to the octahedron face; but the indices are very high numbers.

Observations upon sodium chlorate, zinc sulphate, magnesium sulphate, and other substances show that other crystals exhibit the same behaviour. The faces of a crystal are in general not faces with simple indices, but vicinal planes slightly inclined to them, and they change their inclinations during the growth of the crystal; they also change their inclinations when the crystal is immersed to a greater or less depth in the solution.

Every point within a crystal has at some time been a point on the surface, and has been subject to the conditions of equilibrium is a matter of opinion, and I can understand that as he and Mr. Woodward were obliged to draw a line somewhere for delineation on the map of the Geological Survey they gave the Wealden the benefit of the doubt.

Mr. Andrews and I considered these beds as a continuation of the Upper Purbeck, and we obtained fossils from the material thrown out of a well sunk at the cottages near Dinton Station; it is true that most of the species found range from Purbeck to Wealden, but they included *Cypridea punctata*, which has not yet been recorded from Wealden. The well is 40 feet deep, and the fossils probably came from less than 30 feet down. How much of this thickness is Purbeck and how much Wealden is evidently a matter of opinion and extremely uncertain. The following may be given as a summary of the beds which lie between the Lower Greensand and the Middle Purbeck, near Dinton, with estimated thicknesses:—

	feet.
4. Yellow and grey silty clays by Dallwood Farm ...	15–20
3. Grey silty marl (in the well)	10–12
2. Stiff grey and yellow clays (in the well and cutting)...	25
1. Marls, shales, and grits (in the cutting)	12

No. 1 is Upper Purbeck; No. 2 may be either Purbeck or Wealden; Nos. 3 and 4 are probably Wealden.

4. *Purbeck and Wealden at Teffont.*—When in 1890 Mr. Andrews and I endeavoured to trace the Upper Purbeck and Wealden clays towards Teffont we found that their thickness became very much less, and that the space occupied by their outcrop north of Teffont Rectory was very narrow. We found there exposures of the following beds in descending order:—

D. Black clay.
C. Greenish-black glauconitic sand.
B. Mottled clay, white, yellow, and claret-coloured, like the 'cat's-brain' clay of Kentish Wealden.
A. Yellow silty clays.

The upper two members of this succession we regarded as Lower Greensand (Vectian), the lower two as Wealden, believing A to be part of the Dallwood Farm beds, No. 4 of the series near Dinton. We saw nothing between this and the Middle Purbecks, and there did not seem room for the Upper Purbecks (Nos. 1 and 2) to come in, so that we concluded the Wealden had here overlapped the Upper Purbeck Beds.

From the newly issued 1 inch map I find that Mr. Reid does not carry the Wealden clays so far west as the point where we saw the above succession, but has coloured all the beds north of the Rectory between the Middle Purbeck and the Vectian Sands as Upper Purbeck. It is clear, therefore, that Mr. Reid agrees with us in thinking there is not room enough here for the whole thickness of Upper Purbeck and Wealden, but differs from us in regarding the beds which do occur as Purbeck instead of Wealden. In the explanation of the map (Sheet 298) he does not describe any exposure of these beds north of Teffont, either under the head of Purbeck or Wealden, but quotes our description of them in his chapter on the Lower Greensand, and then remarks that he doubts our correlation of the clays at Dinton and Teffont.

Here, again, therefore, it is a matter of opinion, and those responsible for the published mapping of this bit of ground do not seem able to give very good reasons for their beliefs. We suppose Mr. Reid correlates the yellow silty clay of Teffont with the yellow grey and white clays at the top of the Dinton cutting, but in the latter place there is nothing like the peculiar 'cat's-brain' clay, and until some one can find that kind of clay in the Upper Purbeck of the Vale of Wardour I shall continue to regard it as belonging to the Wealden, and to believe that Mr. Reid has not carried the Wealden far enough to the westward along the northern side of the Vale.

When describing the Purbeck Beds in 1894 we incidentally remarked that there was a complete discordance between the Purbeck Beds and the Lower Cretaceous Series, "including the Wealden." This was carelessly expressed: the great unconformity is undoubtedly at the base of the Lower Greensand, but we certainly did think that the Wealden overlapped the Upper Purbeck. Whether it really does so depends on the correct separation of the Wealden from the Purbeck. The bare idea of a break at the base of the Wealden fluttered the dovecotes of Jermyn Street to such an extent that the question seems to have assumed proportions of paramount importance in the minds of Messrs. Woodward and Reid. Others, however, may deem it of equal importance that the divisions of the Purbeck Series should be established on logical grounds, that the thickness of each group should be carefully estimated, and that the outcrop of the Wealden Beds should be carefully discriminated from that of the Upper Purbecks.

Finally, Mr. Reid's reference to *Endogenites erosa* adds nothing to the strength of his position. He admits that "it is too doubtful a form to be of much value for correlation," but immediately adds, "though its presence supports the view that the strata containing it truly belong to the Wealden period, and are not, as supposed by Messrs. Jukes-Browne and Andrews, of Purbeck age." He quite ignores the fact that we found a large piece of similar endogenous wood in the Upper Purbeck sand of the Dinton cutting. It is also a fact that pieces of *Endogenites erosa* have been found close to the spots where outliers of the Upper Purbeck are shown on the map, and when it is remembered that the fossil wood has never been found in the beds referred by Messrs. Woodward and Reid to the Wealden, it will be apparent that the facts are much more in accord with our view than with Mr. Reid's.

In conclusion, I may place on record that I have submitted one of the surface fragments to Mr. A. C. Seward, and he kindly informs me that he believes it to be the true *Endogenites erosa*, now known as *Tempskya Schimperi*, and in reality the stem of a tree-fern. Unfortunately, I could not send him a piece of the wood found in the sand at Dinton, and cannot therefore affirm that it was also *Tempskya*, but it was so similar that I took it to be the same.

I append a revised estimate of the total thickness of the Purbeck Beds in the Vale of Wardour, if the Upper group is to be restricted within the limits indicated by Mr. Woodward.

	ft.	in.	
Mean thickness from top of No. 30 to base of limestone with *Unio* (part of 21)	12	0	Upper Purbeck, 22 feet.
Yellow sands with *Endogenites*	6	0	
Grey clays and marl	4	0	
Thickness from top of No. 19 to top of the *Archæoniscus* bed (No. 13)	7	0	Middle Purbeck, 22¼ feet.
From top of No. 19 to top of cinder bed (south of Teffont)	4	3	
From top of cinder bed to base of the 'scale' below the flagstone at Teffont	11	0	
From base of 'scale' to marl-band below the 5th Lias	15	9	Lower Purbeck, 64½ feet.
Section in Ridge quarry from marl below 'Lias' to bottom of quarry	19	10	
Allowance for gap between quarries	7	0	
Section at Wockley from surface to base of Purbeck Beds	22	0	
Total	108	10	

IV.—THE DISAPPEARANCE OF LIMESTONES IN HIGH TEESDALE.[1]

By C. T. CLOUGH, M.A., F.G.S., of H.M. Geol. Survey.

IN High Teesdale, on certain hillsides, the structure of which is in most respects clear, the observer is struck by the disappearance of some, generally constant, limestone which ought naturally to occur. The limestone most usually missing is the Great Limestone, which, with the exception of the Melmerby Scar Limestone, is the thickest of all in the dale. Though the ground is almost free from peat and drift, and plainly shows the banks formed by the Four Fathom Limestone and Firestone,[2] there is yet perhaps neither bank nor 'shake-hole' (swallow-hole) to represent the Great Limestone. In the cases referred to the difficulty cannot be accounted for by supposing that the limestone along its outcrop is thrown out by a fault, for the outcrops of the beds above and below can be followed round the hill without interruption.

Where the limestone disappears many masses of sandstone are usually found, most of which seem somewhat disturbed; and, in the small streams, thin irregular bands of soft, rather siliceous, clay and iron ochre occur. The clay and ochre represent the limestone, which, in the language of the dalesmen, has been 'eaten away' along the outcrop and replaced by 'famp.'

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[1] The substance of this communication was written 25 years ago. Since then Mr. F. Rutley has written "On the Dwindling and Disappearance of Limestones" (Q.J.G.S., 1893, vol. xlix, p. 372), but he makes no mention of their special liability to dwindle in the neighbourhood of faults and veins, and gives no instances of their disappearance on a large scale. Mr. J. R. Dakyns has written a short paper "On 'Flots'" (Report Brit. Assoc., 1881, p. 634), and the material in many 'flots' seems of much the same nature as 'famp.' The writer has recently seen an instance of famping, differing somewhat from the examples in Teesdale, in one of the limestones (the Skateraw Middle Limestone), which has been quarried at Catcraig, near Dunbar, and this has recalled the subject to him.

[2] The Four Fathom Limestone is a little below the Great, and the Firestone is a sandstone a little above the Great Limestone.

The best locality for observing 'famp' and the accompanying phenomena is at the Highfield 'hushes,'[1] above Grasshill. It is there seen in clear section that the Great Limestone, the average thickness of which in the neighbourhood is 55 feet, is replaced by 10 or 12 feet of soft siliceous, irregularly banded, ochreous clay. Several veins cross the hushes, and near these veins low rambling levels have been driven in search of lead ore. Such work gives rather uncertain returns, for there are no straight or constant strings of ore to follow, but every here and there nodular masses of ore, occasionally a foot or more in breadth, are met with, which seem on the whole to repay the miners. These masses often occur together in groups, the centre of the larger examples being composed of galena, and the outside usually of carbonate of lead, or of a mixture of carbonate, phosphate, and arseniate. In the smaller, those with a breadth of an inch or less, the mass is often composed throughout of the three last-mentioned ores without any galena. The outlines of most of the lumps are rounded, and they show no sharply defined crystals of galena like those common in the ordinary veins. The miners think that the famp-ore has been water-worn, and they are probably right in one sense, though the carbonate and phosphate of lead, etc., on the outsides of the lumps, are often in well-formed crystals which cannot have undergone rolling.

A few other minerals, associated with the lead ores in the adjacent veins, are also found in the famp. Besides these, there are hard round lumps, each consisting of a limestone centre and an outer coat, which shows a gradual passage between limestone and famp. No sandstone boulders have ever been noticed in famp.

It is usually stated that limestones are not so much famped 'under the hill' as at the outcrops, and the sections at the head of Highfield hushes seem to confirm this opinion. In the gutter made in 1876 to hush part of the famp, a series of small faults and local contortions were seen, which bring down the 'Coal Sills,' the sandstones next above the Great Limestone, to lower levels towards the south, the direction in which the outcrop of limestone should occur. We know that these disturbances do not affect the beds below the famp, for they were not met with in the Cowby level, which is driven nearly under this gutter. They seem due to the dwindling away of the limestone as it comes near the surface. Famp probably replaces the Great Limestone in Yad Moss level, South Lang Tae sike, Blackway Hole hushes, the West Beck and Old Langdon hushes, and Pikelaw hushes. It probably also occurs for most of the way between Blackway Hole and South Lang Tae sike, a distance measured along the outcrop of about a mile, from the Yad Moss level to some distance on the north side of Crook Burn, and for half a mile or more on the north side of Henrake hush.

The areas wherein limestone has been replaced by famp are sometimes sharply defined. In Pikelaw hushes, vertical walls of limestone, 20 or 30 feet high, stand (1876) close against sandstone and shale, but when the margins of the limestone are examined by hushing, .etc., they show no vein, and they do not continue in nearly straight lines as most veins do. Parts of the limestone stand up like ruined towers on the floor of Blackway Hole hush, and it is said they remain much as they were when originally found sticking up in a mass of famp.

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[1] A hush is an artificial wash-out, made for the purpose of baring and cutting the strata and the veins which cross them. In the process of hushing a reservoir is made high on the hill, and the water is let out in a flood along the desired direction.

The famp in the Yad Moss level is mixed with irregular streaks of a black earthy mineral, part of which is probably a black ore of manganese. In the West Beck and Old Langdon hushes the famp consists of nearly pure iron ochre, and it would no doubt have been used for smelting if it had been in a more accessible locality. In Weardale a famp of similar character has long been largely worked for this purpose. The light yellow varieties of famp are sometimes used instead of whitewash, for painting over walls, etc.

The limestones in Teesdale, which, next after the Great Limestone, are most conspicuously famped, belong to the Melmerby Scar group of limestones, in the neighbourhood of Silver Band Mine, Cronkley Fell. These limestones and the Great are generally rather pure limestones (the Great usually contains about 95 per cent. of carbonate of lime), so that the famp cannot be solely the residue of their decomposition. The greater part of it must have been introduced from without. It is most abundant where veins of ore are most numerous, and it is probable that most of the famp material was introduced by the same agent which filled so many of the neighbouring veins with ironstone and other minerals.

Where an ironstone vein passes through limestone, the width of the vein is nearly always greater than in sandstone or shale, for the limestone 'cheeks' are converted into ironstone for a certain breadth at the sides of the vein. The ironstone has not only grown in the open fissure of the vein or fault, but has also replaced part of the limestone. This is shown by the casts of corals, crinoids, etc., which are found in the ironstone. In a similar way, also, where a quartz vein passes through limestone, the limestone on the sides is partly replaced by finely crystallized quartz.

We suppose that the fissures made in the course of earth movements formed channels for the circulation of water holding various minerals in solution, and that this water not only deposited minerals in the fissures, but also gradually dissolved part of the limestone it passed through, and deposited other minerals in its place. The replacement effected along the sides of the veins varies greatly in extent, and it is probable that a replacement by carbonate of iron was the first stage in the manufacture of famp.

But why is the limestone more often dissolved away along the outcrop than elsewhere? It appears as if the action, which was first started by water circulating along the veins, had been continued and modified in recent times, since the present surface of the ground was developed, and that this later action is perhaps still in progress.

It is obvious that where a limestone was already partly dissolved away near the outcrop, the ground above would be affected by local introduced which have not been actually proved to exist within the area.

TABLE OF STRATA FOR THE ISLE OF MAN.

RECENT	Blown sand.	
	Peat.	Fresh-water.
	Alluvium.	
	Raised Beach.	Marine.
GLACIAL	Late Glacial Flood-Gravels.	
	Sand and Gravel occurring as platforms.	
	Sand and Gravel occurring as mounds.	
	Boulder-clay or Loam, and Rubble Drift.	
	Great Unconformability.	
TRIASSIC	Red Marls (saliferous).	Proved in deep borings beneath the drift-plain at the northern end of the island.
	St. Bees Sandstone.	
PERMIAN	Lower Marls and Brockram.	
	Great Unconformability.	
CARBONIFEROUS	Carboniferous Limestone Series.	
	Basement Sandstone and Conglomerate.	
	Great Unconformability.	
UPPER CAMBRIAN?	Manx Slate Series locally divided into	Barrule Slates.
		'*Crush Conglomerate.*'
		Agneash and other Grits.
		Lonan and Niarbyl Flags.
	CONTEMPORANEOUS.	
IGNEOUS ROCKS	Carboniferous	Tuff Agglomerate, etc.
		Basalt.
	Manx Slate Series.	Tuff (*small patches near Dalby only*).
	Intrusive.	
	Olivine Dolerite (Tertiary ?) dykes.	
	Diabase, etc. ('Greenstone') dykes.	
	Diabase, Epidiorite, Chloriteschist, etc. ('Altered Greenstone'), dykes.	
	Diorite and Camptonite dykes.	
	Mica-trap dykes.	
	Microgranite dykes.	
	Granite.	

The geological maps of the island, of which Mr. Lamplugh's memoir contains a very full and admirable description, are issued in two editions, one with and the other without the Drift.

Besides the chapters of topographical details regarding the rocks of the island which are arranged to serve as a geological guidebook to those in search of local information, the work contains general chapters in which a broader method of treatment is adopted and prominence is given to the phenomena of more than local interest. Thus, the descriptions of the physical features of the island, of the 'Crush Conglomerate' and other curious rock structures and types of folding produced by earth-movement in the Manx Slates, of the disturbance of a different character exhibited by the Carboniferous rocks, of the structure of the Irish Sea basin as revealed by deep borings in the north of the island, and of the condition of the island during the successive stages of the Glacial Period,—all contain matter of wide geological interest. The chapters on the petrography of the great variety of most interesting igneous rocks and of those of sedimentary origin have been prepared by Professor W. W. Watts.

Under the heading of Economic Geology there will be found a general account of the rich metalliferous veins for which the island is noted, and a careful description of the very numerous mine workings and trials that have been carried out in exploiting or testing these veins. The book is illustrated by very numerous plates, figures, and sections.

We congratulate the author upon this very excellent and well-prepared volume. But greater attention should be given by the printers to the reproduction of the illustrations in the text, which still leave much to be desired. The collotype plates are admirable, and mark a distinct advance in the publications of the Geological Survey.

III.—MEMOIRS OF THE GEOLOGICAL SURVEY OF SCOTLAND.

1.—The Geology of Lower Strathspey (Explanation of Sheet 85). By L. W. HINXMAN, B.A., F.R.S.E., and J. GRANT WILSON; with Petrological Chapter and Notes by J. S. FLETT, M.A., M.B., C.M., D.Sc. 8vo; pp. vi and 92, with 3 plates and 3 text figures. (Printed for H.M. Stationery Office by James Hedderwick & Sons, Glasgow. J. Menzies & Co., Edinburgh (or of Messrs. Dulau & Co., 37, Soho Square, London, W.), 1902. Price 1*s.* 6*d.*)

THIS memoir describes the geology of Lower Strathspey, a district embracing 432 square miles in the counties of Elgin and Banff. Special attention is given to the development of the topographical features of the region. The metamorphic and igneous rocks are described, and a section is devoted to the petrography of the area by Dr. J. S. Flett. In connection with the Old Red Sandstone of Lower Strathspey, reports are given in the Appendix by Dr. R. H. Traquair, F.R.S., "On the Fishes of the Old Red Sandstone," and Mr. R. Kidston, F.R.S., on the fossil plants of the Old Red Sandstone of Scotland. The glacial deposits and economic products are described. The three process plates are excellent. A bibliography is given, and an index completes the work, but the geological map (Sheet 85) does not accompany the memoir.

2.—The Geology of Eastern Fife: being a description of Sheet 41 and part of Sheets 40, 48, and 49 of the Geological Map. By Sir ARCHIBALD GEIKIE, D.C.L., F.R.S.; with an Appendix of Fossils by B. N. PEACH, F.R.S. 8vo; pp. xvi and 422, with 12 plates and a geologically coloured map and 71 figures in the text. (Printed for H.M. Stationery Office by James Hedderwick and Sons, Glasgow. J. Menzies & Co., Edinburgh (or of Messrs. Dulau & Co., 37, Soho Square, London, W.), 1902. Bound in cloth boards; price 8*s.*)

The memoir (like that by Mr. Lamplugh on the Isle of Man) is quite up to date, being issued bound in cloth, and accompanied by 12 plates and a geologically coloured map of Eastern Fife, besides numerous figures in the text. It is a district long since explored by the Geological Survey for Scotland; and when its author, Sir Archibald Geikie (the late Director of the Survey), was quite a young man (engaged in planting the laurels which he now so gracefully wears) he wrote an admirable article on Old Volcanic Action at Burntisland (Fife) on the north shore of the Firth of Forth, and described a volcanic bomb he had observed in Carboniferous beds at King's Craig in 1862 (see GEOL. MAG., Vol. I, 1864, pp. 22–26).

The district described in this volume comprises that portion of the county of Fife which lies to the east of a north and south line drawn from the mouth of the River Leven on the Firth of Forth to Wormit Bay on the Firth of Tay. It completes the description of the geology of Fife, of which the first part, comprising the central and western divisions of the county, was published at the close of the year 1900. The account here given of the general geological structure of the ground and the distribution of the rocks has been based partly on the original field-maps just referred to and partly on copious detailed notes made by the author during repeated traverses of the ground. Having in earlier years had frequent opportunities of visiting the east of Fife, he had become familiar with its geology. But for the preparation of this memoir Sir A. Geikie spent a portion of the Spring of 1900 in examining many of the more important sections, and he also devoted the Summer and a portion of the Autumn of 1901 to the same purpose.

The unique feature in the geological history of this part of Central Scotland is presented by the series of some 80 volcanic vents distributed in a band, which crosses the peninsula from Largo to St. Andrew's Bay. Many years ago the author called attention to the nature and interest of these vents, and pointed out how important is the evidence which they furnish as to the internal structure of volcanoes. But up to the present time no complete and detailed account of the whole series of them has ever been published. He has accordingly made a renewed study of the subject, and has devoted four chapters to a full presentation of the facts and a discussion of their bearing on the history of volcanic action in this country.

The author acknowledges his great indebtedness to the late Mr. J. W. Kirkby for valuable assistance given him in preparing his account of the Carboniferous formation of the East of Fife. He generously supplied detailed tables of the coast-sections and careful manuscript notes (both palæontological and stratigraphical), which will be found embodied and indicated in this volume. No such careful and detailed work has been made of any part of the Carboniferous system of the British Islands as that carried out by Mr. Kirkby on the shores of Fife.

Mr. C. D. Geddes, mining engineer of Edinburgh, has furnished the author with records of all recent borings in East Fife in search of coal; but of late years little has been done to develop the mineral fields of the district, so that the maps remain much the same as when surveyed 40 years ago by Mr. H. H. Howell.

In the Appendix Mr. B. N. Peach, F.R.S., Mr. C. B. Crampton, and Mr. D. Tait furnish a general list of all the fossils obtained in Eastern Fife; assisted by Dr. R. H. Traquair, F.R.S., for the Fishes; Dr. Wheelton Hind for the Mollusca, etc.; Mr. R. Kidston, F.R.S., for the fossil Plants; Prof. T. Rupert Jones, F.R.S., and the late Mr. J. W. Kirkby for the Entomostraca, etc. These are arranged in stratigraphical groups, in botanical and zoological grade, and the localities are all given by means of numbers. Special lists of fossils are also added. The series of 12 plates are devoted mostly to volcanic and glacial phenomena, which the coast of East Fife admirably illustrates. We are glad to see the historic 'Rock and Spindle' still stands on the beach two miles east of St. Andrew's. This might, with advantage, have been reproduced on a larger scale, so as to bring out more effectively its remarkable features. Dr. J. S. Flett and Mr. H. J. Seymour contribute a chapter on the petrography of some of the rocks of Eastern Fife, and one recognises many effective sketches of geological phenomena from the notebook of Sir A. Geikie, reproduced as process cuts in the text. Certainly the King's printers in Scotland do their work better than those for England, and unless our London printers look carefully to their laurels the memoirs of the Survey are apt to be sent 'over the border' for production.

IV.—The Geological Survey of Ireland.

The Geology of the Country around Dublin (Explanation of Sheet 112). By G. W. Lamplugh, F.G.S., J. R. Kilroe, A. M'Henry, M.R.I.A., H. J. Seymour, B.A., F.G.S., and W. B. Wright, B.A. 8vo; pp. viii and 160, with 5 plates and 21 process illustrations in the text, and a coloured geological map (Sheet 112). (Printed for H.M. Stationery Office by Alex. Thom & Co., Limited, Dublin. Sold by Hodges, Figgis, & Co., Limited, 104, Grafton Street, Dublin (or of Dulau & Co., 37, Soho Square, London, W.), 1903. Price 3*s.*; price of Map 1*s.* 6*d.*)

[In part reprinted from the explanatory Memoir to accompany Sheets 102 and 112, by J. Beete Jukes, M.A., F.R.S., and G. V. Du Noyer, 1861; revised 1875.]

This memoir has been prepared to accompany and explain the new colour-printed drift-map of Dublin and its environs. The description of the 'solid' rocks is mainly reprinted from the original "Memoir to accompany Sheets 102 and 112," which has long been out of print, but this part has been expanded to include a summary of the researches carried out by private workers and by the Survey since that memoir was published, and a newly written portion dealing with the 'petrography' of these rocks has also been added.

The description of the glacial drifts and other superficial deposits is altogether new, and contains the information collected during the survey of these deposits in the year 1901. The material under the heading of 'Economic Geology' has been greatly enlarged from the previous memoir, and now includes a list of the minerals of the district and an account of researches into the character of its soils.

The previous geological literature of the neighbourhood is also for the first time discussed, under the heading of 'Bibliography,' and a list of this literature is given in an appendix. The memoir is illustrated by 5 plates from photographs, by R. Welch, of Belfast, and by 21 figures in the text.

The district included in this sheet lies wholly within the county of Dublin. The city of Dublin is in the centre of the sheet, and its suburbs extend along the shores of Dublin Bay to Dalkey on the south and Dollymount on the north, and also along the Liffey valley westward to Chapelizod. The watering-places of Howth and Killiney lie respectively north and south of Dublin Bay within the sheet, and the islet of Ireland's Eye occurs within its northern margin.

The southern part of the district is high mountainous ground, rising up to 1,763 feet above the sea at a point called Fairy Castle. There is another summit called Tibradden Mountain, which is 1,540 feet; and the better known Three Rock Mountain, everywhere visible from the neighbourhood of Dublin, is 1,479 feet high. A hill called Slieve na bawnoge at the extreme south-west corner is 1,265 feet. Of the lower hills, Killing Hill has a height of 512 feet, while the summit of that of Dalkey is 472 feet high, within a quarter of a mile of the sea. The mountains, like all granite mountains, have heavy-looking, gently sweeping summit outlines, their flanks descending gradually but rather steeply on the east towards the sea, and on the north to the plain traversed by the Dodder and the Liffey.

This plain spreads northwards from the foot of the hills, with gentle undulations of between 100 and 200 feet above the sea, rarely rising above the greater height, and often, especially near the sea or on the margin of brooks and rivers, falling below the lesser altitude. It forms a portion of the central plain of Ireland. In the north-western part of the map, however, north of Finglas, the land rises to a height exceeding 300 feet, and the rocky promontory of Howth has a summit of 560 feet in height. All the north-flowing drainage of the southern hill range is received by the River Dodder, which swerves eastward across the plain to the mouth of the Liffey, after issuing from the mountains through the deep hollow of Glenasmole, a little south of Tallaght. The eastern portion of the range is drained principally by two small streams which flow eastward into Killiney Bay. The Liffey, which has a level of less than 40 feet where it enters the district, brings the drainage from the plains of Kildare into the head of Dublin Bay, into which also runs the lesser river Tolka, with a course parallel to the Liffey, and only one to two miles further north.

The solid rocks of the district are shaly and massive Carboniferous Limestones, Lower Limestone shales and fine grits, Lower Silurian, Bala, and Llandeilo beds, altered Silurian grits and shales, Cambrian quartz rock, granite and basaltic andesites.

The memoir deals with (1) the solid geology; (2) the palæontology; (3) the petrography; (4) the relation between the external form of the ground and its internal structure, and hereunder to the consideration of Glacial and post-Glacial deposits ıd their origin; (5) the detailed description of the solid rocks) the detailed description of the drifts.

Then we come to the section Economic Geology—to the subject of ineral lodes, building materials, water supply, and agricultural ology.

Treated economically, the drifts are composed of blown-sand orming sandy hillocks), recent intake (forming silt and made ound), alluvium, silty and loamy river-flats, peat and peaty-posits. Raised beaches, pebbly sandy flats, river-gravel terraces hese are usually from 1 to 3 feet of loam on gravel). Late Glacial od-gravel (forming stony loam on gravel tending to be water-gged). Sands and gravels of mounds and Eskers (forming dry ony loam on gravel, usually full of limestone). Sand and gravel tercalated in Boulder-clay (forming soil nearly like that of Boulder-ty). Boulder-clay containing much limestone (forming clayey am with stones). Clayey drift mainly of non-calcareous material, cluding later hill-wash (forming a light, stony soil, varying with aracter of subjacent rock).

The five plates are admirably reproduced and well printed. There e also 21 sections and illustrations in the text, including a figure of *dhamia*, which is a very old friend indeed. The memoir will prove ery useful addition to the series of Geological Survey publications.

V.—EGYPTIAN GEOLOGY.

vey Department, Public Works Ministry [Egypt]. Geological ırvey Report. Topography and Geology of the Eastern Desert Egypt, central portion, by T. BARRON and W. F. HUME. o; pp. xii, 332, with maps, plates, and sections. (Cairo,)2 [so dated, but issued May, 1903]. Price 400 milliemes . 4*d*.).)

his Report, which has been expected for many months, the :cellent arrangement of previous reports is followed of first a complete topographical survey of the region to be ically surveyed. This brings together a great deal of useful ıl relating to Egyptology, meteorology, botany, and zoology, iderable value when dealing with a new area, the features ountry being illustrated by a series of beautiful photogravures ng scenery and points of geological interest.

eology is the result of an examination by two parties of the ing 1897–98, and the succession of beds dealt with includes ne, Pliocene, Miocene, Eocene, Cretaceous, all resting on and metamorphic rocks. The whole of the volcanic and hic beds (with the exception of a few noted in the text) ı planed down by marine erosion, and the Nubian has been laid down on the smoothed surfaces. This ndstone is considered by the authors to be of Santonian r Cretaceous), there being no proof of beds older than in the district. The Cretaceous limestones overlying Sandstone are mainly Middle Senonian (Campanian).

There is a marked unconformity between these strata and the overlying Eocene shales and limestones, which consist of two divisions, the Serrai limestones and the Esna shales, respectively of Londinian and Suessonian age. Andesites have been intruded into these beds, which are succeeded by Pliocene rocks, Oligocene being absent, and Miocene beds occurring only in the extreme north-east of the area. The Red Sea is considered to have come into existence in late Pliocene times, as the highest coral reefs (200 metres above sea-level) contain a possible mixture of Pliocene and Pleistocene corals. The youngest coral reefs are associated with gravels and conglomerates which must be of Pleistocene age.

Special chapters are devoted to Economics, which include gold and petroleum, and an interesting discussion is raised on the "Influences giving rise to the Eastern Desert structure." These influences may be summed up as follows:—(1) Its geological structure; (2) tectonic movements, folding and faulting, breaking up the plateau into isolated areas; (3) water; (4) insolation and changes of temperature; (5) mineral composition of the rocks and differences of their coefficients of expansion; (6) the dykes, as strong determinative factors in the hill sculpture; (7) wind, only effective where it has a supply of sand and plenty of space to act; (8) Nubian sandstone, and not granite, is the source of the sand; (9) sand action, in eating away the limestones along previously formed cracks.

The general get-up of the volume is highly satisfactory, the printing of the text, maps, and sections, which has all been done in Cairo, is excellent, the photogravures are by Albert, of Munich, and there is a singular absence of misprints. There is a voluminous index and a good bibliography, both quite indispensable to such a report. We would, however, ask the Director to insert the word "Egypt" after the word "Ministry" in the covers and title-pages of these reports, and to believe that the future difficulties which will arise from a book dated 1902, but not issued till 1903, are more real than at first sight appears. We are grateful for the list of publications which appears on the back of the cover, for in an unnumbered series of publications one is never certain how complete or incomplete one's set may be. C. D. S.

VI.—NOTES ON CAMBRIAN FAUNAS. By G. F. MATTHEW, LL.D., with description of a new species of *Metoptoma*. (Trans. Roy. Soc. Canada, series II, vol. viii, sec. iv, p. 93.) 1903.

THIS article deals with several subjects relating to the Cambrian faunas of Canada. In the first note the differences in musculation, circulatory system, etc., of the Oboloid shells of the Cambrian in Canada are described. It is claimed that these shells belong to several subgenera. All but one are older than the type of the genus, *Obolus Apollonis*.

In the second note the enlargement during Cambrian time of the shells of several genera of Cambrian Inarticulate Brachiopoda is shown to have taken place.

In the third note proofs are shown that favour the view that the Upper Etcheminian fauna (Basal Cambrian) invaded Eastern Canada from the south-west.

In connection with the fourth note, in which the Brachiopodous shells of the Cambrian fauna of Mt. Stephen in British Columbia are dealt with, is the description of a new species of *Metoptoma.*

REPORTS AND PROCEEDINGS.

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GEOLOGICAL SOCIETY OF LONDON.

I. — April 29th, 1903. — J. J. H. Teall, Esq., M.A., F.R.S., Vice-President, in the Chair.

Prof. Bonney, in exhibiting three specimens found by Prof. Collie, F.R.S., on Desolation Valley Glacier, east of the watershed of the Rocky Mountains and a little south of the Canadian Pacific Railway, pointed out that one, a slab of white quartzite, was covered by horizontal worm-burrows, often about one-third of an inch in diameter, such as those named *Planolites* by Nicholson; another, of the same material, had blunt ridges, tapering to a point, an inch or so long, rudely parallel, in sets of about four. These he should have taken for the tracks of a (?) Crustacean, but they were single, not paired, and without any sign of a medial furrow. The third was a slab, measuring about 11 by 5 inches and 1½ inches thick, of a brownish quartzite, passing quickly on one side into a green argillite, the other side being thickly studded with dome-like eminences about an inch in diameter and nearly half this in height. Most of them show a slight 'dimple' at the top, and a very slight 'step' or swelling often forms a sort of ring part way up the dome. Some argillite, like that on the other side, remains about their bases, and a few tracks of *Planolites* wind among them, and once or twice seem to pass over them. The domes are formed of a quartzite, identical with that of the slab. It shows a very faint stratification, and consists of grains of quartz, not seldom well rounded, embedded in a minutely micaceous matrix, probably an alteration product of felspar. They cannot be concretions; so the speaker regarded them as the casts of pits in the argillite, made by a large annelid, which retreated into it vertically (? *Scolithus*), afterwards filled up by a layer of sand.

The following communications were read:—

1. "The Age of the principal Lake-Basins between the Jura and the Alps." By Charles S. Du Riche Preller, M.A., Ph.D., A.M.I.C.E., M.I.E.E., F.R.S.E., F.G.S.

(1) In a paper read before the Society last session, the author showed, on the evidence of extensive high-level deposits of Deckenschotter in Subalpine France and Switzerland, that the principal Swiss lake-basins could not have existed at the time when those deposits were formed, during and after the first or Pliocene glaciation of the Alps. In the present paper he deals with the question reserved in the preceding one, that is, to which subsequent period the formation of those lake-basins should be assigned. By the light of further

recent investigations in the different localities, he first considers the conditions of the Zurich lake-valley, where the successive glacial and fluviatile deposits are clearly defined, and then applies his conclusions to the other principal lake-basins lying in the same zone along the edge of the Alps.

(2) The hitherto generally accepted view that the lake-basins are pre-Glacial in the old sense, or were formed during the first inter-Glacial period, rests, in the main, on two arguments: (1) that the alluvia at the lower ends of the lakes are all Glacial, not only from their appearance, but because the materials composing them could only have been transported thence by glaciers, which either passed over the lakes by bridging them, or through them by completely filling them with ice; and (2) that the zonal bending of the Molasse along the edge of the Alps, to which the lake-basins owe their existence, occurred before the second or maximum glaciation, because at a point in the Lorze ravine (near the Lake of Zug) the Deckenschotter conglomerate dips reversely, that is, up the valley, while the overlying, younger, loose gravel dips in the opposite direction.

(3) The author adduces evidence to show that the deep-level gravel-beds in the Limmat Valley near and below Zurich are essentially fluviatile, composed of the characteristic Alpine material of the Rhine and Linth drainage areas, and in all other respects similar to the gravel carried by the River Sihl at the present day. These gravel-beds rest upon Glacial clay of the second glaciation, which fills the Molasse-bed of the valley to a great depth, and are overlain by the moraine-bars and secondary products of the third glaciation, the latter being overlain by and mixed with the post-Glacial alluvia of the Sihl.

(4) He further argues that it is, on mechanical grounds, difficult to conceive how glaciers could either bridge, or completely fill with ice, such extensive basins as those of the principal Alpine lakes, from 2 to 8 miles in width and from 470 to 1,020 feet in depth, the quantity of water to be displaced and expelled in the individual cases ranging from 3,500 million to 90,000 million cubic metres or tons.

(5) As regards the more recently enunciated argument of the Deckenschotter and overlying gravel exposure in the Lorze Valley, the author points out that, apart from the difficulty of differentiating the second and third glaciation materials in that locality, it is obviously hazardous to deduce from a purely local phenomenon of this kind, and more especially from any dip of loose gravel—in contrast with rock or compact conglomerate—the date of the zonal bending affecting six valley systems, and extending over more than 200 miles along the edge of the Alps.

(6) The author's investigations point to the conclusion that the deep-level Limmat gravel-beds, overlain by the moraine-bars of the third glaciation, were deposited by a river during the second inter-Glacial period; that the lowering of the valley floor was initiated in the course of the third glaciation, probably when the

glacier had already reached its maximum extension, about 10 mil below Zurich; that the zonal subsidence continued throughout tl retreat of the ice; and that the simultaneous formation of the lak basin should therefore be assigned to the end of the Glacial Perio after which the original basin was, notably at its upper en restricted to its present dimensions by post-Glacial alluvia.

(7) In conclusion, the author shows that the same argumen apply, in the main, also to the origin and age of the other princip zonal lake-basins, which he illustrates by longitudinal sections. I his view, the position and depth of these basins, as well as tl intervening ground, point to the probability that the bending too place not only along one line, but along several, more or le parallel, not always continuous lines within the zone between the Al and the Jura; that the bending was by no means of uniform depth and that, therefore, the Alps did not subside as a rigid mass, b that the zonal bending along their edge merely extended locally f some distance from the deepest points of the lake-basins along tl floors of the principal Alpine river valleys.

2. "On a Shelly Boulder-Clay in the so-called Palagoni Formation of Iceland." By Helgi Pjetursson, Cand. Sci. Na (Communicated by Prof. W. W. Watts, M.A., M.Sc., Sec. G.S.)

There is no equivalent in the Tertiary basalt plateaux of Brita of the great palagonite formation of Iceland, which Prof. Thoroddse has shown to be younger than the basalt formation of the latt island. The basement layer of the breccia formation, restin directly upon the basalts, contains glaciated blocks of all sizes, up t 6 feet and more in diameter. These ground-moraines are followe by tufaceous sandstones, conglomerate, columnar basalts, othe ground-moraines, and volcanic tuffs and breccias. At Birlandshöf a shelly Boulder-clay, 70 to 80 feet thick, rests upon the fundament basalt, which here shows a glaciated surface. Unbroken shells a very rare. *Astarte borealis* is the most common shell, and *Saxica arctica* and *Mya truncata* are less common, indicating that some the older moraines are of Pleistocene age. The author conclude that volcanic activity did not pause in Iceland during the Glaci Period, but that it was especially active at the beginning and th close of glaciation, building up bulky hills of slags and ashes, som of which have survived the Glacial Period as volcanoes, while othe have become extinct. Volcanic activity had died out in Britain this time, and hence the palagonite formation is unrepresented i that country.

II.—May 13th, 1903.—Edwin Tulley Newton, Esq., F.R.S., Vic President, in the Chair. The following communications we read:—

1. "On some Disturbances in the Chalk near Royston (Hertfor shire)." By Horace Bolingbroke Woodward, Esq., F.R.S., F.G.S.

A 'line of flexure' is marked on the Geological Survey map fro Therfield, south-west of Royston, in Hertfordshire, to near Heydo in Cambridgeshire, a curved line a little below the crest of the Upper Chalk escarpment. The author in 1902 found evidence which satisfied him that the disturbances, previously supposed to be an anticline, were due to glacial action, a view confirmed during the present year. Four sections are described: Great Chishall, Pinner's Cross, the Limekiln south-west of Newsell's Park and north of Barkway, and north of Reed. The disturbed Chalk near Royston, with its fractured and displaced flints, occurs in conjunction with Boulder-clay, and the latter is found beneath a considerable thickness of disturbed Chalk. This is compared with similar phenomena near Trimingham, and at Litcham in Western Norfolk. While Boulder-clay occurs along the high ground bounding the disturbed area to the south, the vale and undulating downs immediately to the north are devoid of this Glacial Drift. The facts were to be explained, on the land-ice theory, if the ice were at first welded to the rubbly surface strata in regions north of the escarpment, and, when movement set in, there were overthrusts of débris-laden ice, and upper layers of ice were rent asunder from and moved over lower ones; while to the thrust or long-continued pressure of ice along shear-planes at the higher levels may be attributed the belt of disturbed strata. Certain patches of esker-like gravel in Wardington Bottom might be explained by streams due to the melting of the ice banked up against the scarp; and we might go some way with Sedgwick in believing that the outlines of the combes "do not appear to have been produced by a long-continued and slow process of erosion; but rather to have been cleanly swept out by rapidly descending water-floods."

2. "On a Section at Cowley, near Cheltenham, and its bearing upon the Interpretation of the Bajocian Denudation." By Linsdall Richardson, Esq., F.G.S.

According to Mr. Buckman's map, published in 1901, the Upper *Trigonia* Grit should have been seen at this spot to rest directly, and non-sequentially, upon the Upper Freestone, whereas observation shows the intervention of at least the *Buckmani* Grit, part of which thins out from 4 inches at the north-eastern end to nothing at the other end of the quarry, which is in the direction of the anticlinal axis. The error is not one of fact, but of inference, and the present evidence rectifies portions of those limits which were drawn theoretically. A section near the "Air Balloon" Inn, on the road from Birdlip to Cheltenham, shows the Lower *Trigonia* Grit covered by *Buckmani* Grit and underlain by the Upper Freestone. There is only one section where the Upper *Trigonia* Grit is seen to rest directly upon the Lower *Trigonia* Grit, the latter being only 3 feet 2 inches thick. The causes producing the Bajocian denudation appear to have been forces so acting as to effect a repetition of flexure along old lines of weakness (Aalenian); and thus in the Birdlip area an anticline may be again located, but the elevation was this time much greater: indeed, the level of the Aalenian denudation was passed by the Bajocian. Other sections near Brimpsfield and in Cranham Wood are given in connection with the location of the anticlinal axis. The exact location of the anticlines and synclines of the Inferior Oolite rocks in the Cotteswolds, where sections are numerous, may afford some important working hypothesis for unravelling the structure of the Vale of Gloucester, where excavations are few.

3. "Description of a Species of *Heterastræa* from the Lower Rhætic of Gloucestershire." By Robert F. Tomes, Esq., F.G.S.

The specimen described was obtained by Mr. L. Richardson from Lower Rhætic beds at Deerhurst (Gloucestershire). It occurred a little way above the bone-bed; it is specifically and generically new to the Rhætic, and it displays Jurassic relationships. It differs from the several Liassic species in the small size of the corallum and of its calices. Remarks on some other Madreporaria from the Rhætic and from the basement of the Lower Lias are appended. It has always been the author's opinion that the Sutton Stone containing Rhætic Madreporaria should be classed as Rhætic; indeed, he believes that it is really Upper Rhætic; and in view of the very close affinity of its organisms with those of the Lower Jurassic, and bearing in mind the great importance of the Ammonite zones as a means of classification of the Liassic deposits, he asks whether the zone of *Ammonites planorbis* should not be taken as the bottom of the Lias.

III.—Mineralogical Society, March 24th.—Dr. Hugo Müller. F.R.S., President, in the chair. Dr. A. Hutchinson described some remarkably interesting experiments which he had made on the diathermancy of antimonite. A cleavage flake of antimonite 0·29 mm. thick and 20 sq. mm. in area, perfectly opaque to light, was placed between cross nicols and exposed to the radiation from a limelight. The plate was somewhat transparent to radiant heat, and the amount transmitted was measured by Boys' radiomicrometer. No heat was transmitted when the planes of symmetry of the crystal coincided with the planes of polarisation of the nicols, but the maximum effect was produced on the radiomicrometer when the plate was turned through 45° in its own plane. The results so far arrived at are in harmony with the orthorhombic symmetry attributed to antimonite. Mr. J. B. Scrivenor described the occurrence of magnetite in the Upper Bunter Sands at Hinksford, near Stourbridge, and of anatase in the Trias of the Midlands. The crystals of magnetite, measuring on an average ·067 mm., were in cubes or octahedra. The mode of occurrence and the presence of a single set of striations parallel to the cube edge, suggest that they are pseudomorphous after iron pyrites. The anatase, in crystals from ·025 to ·06 mm., is found more abundantly in the Keuper than in the Bunter. The crystals show the forms (111) and (001), and according to the predominance of either form are pyramidal or tabular in habit. Many of them are attached to leucoxene derived from ilmenite or sphene. The anatase has been formed *in situ*, after the deposition of the sandstone, as a decomposition product of other titaniferous minerals. Professor W. J. Lewis described a large crystal of sartorite from the Binnenthal measuring 4″ × 1″ × ⅓″. An analysis by Mr. Jackson gave the following result: Pb = 42·93, S = 25·32, As = 31·11. Professor Lewis also discussed some peculiar twinned crystals of copper-pyrites and cerussite. Mr. W. B. Giles contributed notes on Howlite and other borosilicates from the Borate mines of California. One of these, for which the author proposes a new name, is a white amorphous mineral resembling in appearance pandermite; the results of two closely agreeing analyses of material from different localities corresponded to a formula $8\,CaO . 5\,B_2O_3 . 6\,SiO_2 . 6\,H_2O$. Mr. Giles also described a tantalite from Green Bushes, West Australia, which contained 85 per cent. of tantalic with very little niobic acid. Mr. J. Allen Howe exhibited specimens of peculiar pseudo-stalactitic growths of calcite from the North of England.

CORRESPONDENCE.

THE ZONE OF *MICRASTER PRÆCURSOR*.

Sir,—On pp. 51 and 54 of "The Geology of the country around Salisbury" (Mem. Geol. Surv., Sheet 298) the term 'zone of *Micraster præcursor*' is used. As one who is not a little interested in the genus *Micraster*, and more especially perhaps in the group-form which is known as *Micraster præcursor*, I would crave a little information as to the reasons which have guided the author of this memoir in finding a new zonal title.

Possibly the use of this urchin as a name-fossil is not new, and in that case I must plead guilty to having failed to notice the first occasion of its use. If, on the other hand, this be the first publication in which it has been employed, it would not be unreasonable to expect some statement concerning a fortunately rare event—the adoption of a new name-fossil for one of the zones of the White Chalk. Arthur Rowe.

1, Cecil Street, Margate.
May 6th, 1903.

SAND-DRIFTING AND SEDIMENTATION.

Sir,—I have read Professor Blake's papers on sedimentary deposits with much interest. So far as I can judge, my election to the General Committee of the British Association in 1879 was due chiefly to my work on this subject, and especially to a paper published in 1878, "Notes on Torbay." Such being the case I very naturally made several attempts to elicit discussion in Section C; but at that time geologists absolutely refused to look at the subject. In 1886 I made a number of special experiments, but the Committee of Section C at Birmingham not only omitted even to include my paper ("Deposition and Denudation, etc.") in the list for reading which was published at that meeting, but for the first time omitted my name from the Committee. Ultimately an influential friend remedied both defects, and I was able to read a six minutes abstract in the subsection on the Wednesday morning. This enabled me to get a page of abstract into the Report. The double rebuff was too marked to be mistaken. I found the repugnance to the subject as strong at the Geological Society as at the British Association, and with much regret was forced to drop it. At the time I had a yacht, an experimental tank, a moorland river, and a mill leat; and all the experts whose opinion was of value were favourably disposed towards my work, including Sir G. G. Stokes, Lord Rayleigh, Dr. Sorby, and Mr. Gwyn Jeffreys.

At the Bradford meeting, in 1900, I was interested to hear Dr. Vaughan Cornish state publicly from the platform of Section C that he had only tripped me up once. And that happened to be a quotation and an ambiguously worded passage. It was a trip more than a stumble.

I am not at all surprised at the opposition I encountered in petrological work. That was simply a case of amateur methods of research *versus* professorial. But the opposition to my work on the subject for which I was elected to the General Committee, and which my judges were scarcely qualified to condemn, I have never in the least understood. The standing difficulty is this, that some of the most important textbooks are misleading, and, indeed, I very really hear anyone touch on the subject without their running foul of first principles. In 1882 I submitted a paper to the Royal Society on Ripple-mark. It was officially suggested to me that I had not considered Dr. Sorby's work. Well, Dr. Sorby had supplied me with a sheaf of his reprints, and I did not want to appear to be criticising his observations on 'ripple-drift,' when I was investigating another cause of ripple-mark, viz. wave-action. There are three great principles which have to be considered, viz.: (1) the *drifting* of sand by rivers and currents, as studied by Dr. Sorby; (2) the conveyance of sediment in *suspension*; (3) the disturbance of the already *deposited* sediment by waves of different sorts; and (4) the *redistribution* of this sediment by a great variety of currents. I rejoice to see Professor Blake's papers, as they show that geologists are now alive to the great importance of this subject, a subject which is illustrated by every fragment of sedimentary rock cracked under the geologist's hammer.

It is scarcely worth while to refer to my own writings, as they are fragmentary and scattered almost beyond my own knowledge. I found that if I had got hold of a really important fact, that was just the fact which, being unorthodox, would fail to get into print. I happened to have the monopoly of a new source of information, an experimental tank; so my various judges were sceptical, and my judges were all-powerful. A. R. Hunt.

OBITUARY.

WILLIAM TALBOT AVELINE, F.G.S.

Born 1822. Died May 12, 1903.

The death of W. T. Aveline, at the age of 81, has removed one of the earliest field-geologists attached to the staff of the Geological

Survey under De la Beche. He was appointed an Assistant Geologist in 1840, and after working for a short time in Somerset on the Mendip Hills, he was transferred to South Wales, and surveyed parts of Pembrokeshire. Thence he worked through other counties into North Wales, across the borders into various portions of the West of England, and into the Midland counties as far as Nottingham.

In 1867 Mr. Aveline was appointed District Surveyor to take charge of the mapping of the Lake District, and he resided at Kendal until his retirement in 1882, when he went to live at Wrington in Somerset.

All formations, from the very oldest up to the Eocene, came from time to time under notice, but his chief work was among the Silurian and older rocks. Although painstaking and accurate in his mapping, he went but little beyond the actual survey of the ground. He entered neither into the petrology nor palæontology of the rocks; nor was he given to writing. The maps and sections of the Geological Survey form the chief monument of his labours; and it was in recognition of these, that he was awarded the Murchison Medal in 1894 by the Council of the Geological Society. His portrait will be found in Sir Archibald Geikie's Memoir of Sir A. C. Ramsay (1895).

The following is a list of his published memoirs and papers:—

Geological Survey Memoirs.

1858. "Geology of parts of Wiltshire and Gloucestershire." (With Ramsay and Hull.)
1860. "Geology of part of Northamptonshire."
1861. "Geology of parts of Northamptonshire and Warwickshire."
1861. "Geology of the country around Nottingham." 2nd ed., 1880.
1861. "Geology of parts of Nottinghamshire and Derbyshire." 2nd ed., 1879.
1863. "Geology of part of Leicestershire." (With Howell.)
1872. "Geology of the country around Kendal, Sedbergh, Bowness, and Tebay." (With Hughes.) 2nd ed., revised by Strahan, 1888.
1872. "Geology of the neighbourhood of Kirkby Lonsdale and Kendal." (With Hughes and Tiddeman.)
1873. "Geology of the southern part of the Furness District in North Lancashire."
1880. "Geology of parts of Nottinghamshire, Yorkshire, and Derbyshire."

Other Works.

1848. "Sketch of the Structure of parts of North and South Wales" (with Ramsay): Quart. Journ. Geol. Soc., vol. iv, p. 294.
1854. "On the 'Caradoc Sandstone' of Shropshire" (with Salter): ibid., vol. x, p. 62.
1866. "The Longmynd and its Valleys" (letter): Geol. Mag., Dec. I, Vol. III, p. 279.
1869. "On the Relation of the Porphyry Series to the Skiddaw Slates in the Lake District" (letter): ibid., Dec. I, Vol. VI, p. 382.
1872. "On the Continuity and Breaks between the various Divisions of the Silurian Strata in the Lake District": ibid., Dec. I, Vol. IX, p. 441.
1876. "Absence of the Llandovery Rocks in the Lake District" (letter): ibid., Dec. II, Vol. III, p. 282.
1876. "The Silurian Rocks of the Lake District" (letter): ibid., p. 376.
1876. "The Graptolitic Mudstones of the Lake District" (letter): ibid., p. 527.
1877. "The Magnesian Limestone and New Red Sandstone in the neighbourhood of Nottingham": ibid., Dec. II, Vol. IV, p. 155.
1877. "The Relation of the Permian to the Trias" (letter): ibid., p. 380.
1893. "The St. Bees Sandstone" (letter): ibid., Dec. III, Vol. X, p. 87.
1899. "Geology of the country around Carlisle" (letter): ibid., Dec. IV, Vol. VI, p. 335.

MISCELLANEOUS.

MR. C. L. GRIESBACH, C.I.E., F.G.S., DIRECTOR OF THE GEOLOGICAL SURVEY OF INDIA.

The occasion of the retirement of Mr. C. Ludolf Griesbach, C.I.E., F.G.S., etc., from the post of Director of the Geological Survey of India, which took place on February 24th, 1903, enables one appropriately to refer to his past services in the cause of geological science.

Mr. C. L. Griesbach belongs to an old Hanoverian family, and his grandfather settled in England in the time of H.M. King George III. Most of his family were celebrated as musicians; one of his uncles, the Rev. W. R. Griesbach, held a church living in Yorkshire, and was interested in geology. In his early life Mr. Griesbach's family resided in Austria, and as a young man he joined the Geological Survey in Vienna, and became by that means an excellent field geologist and palæontologist. He was also an accomplished artist. In 1869 he was chosen to join a German expedition to explore the then but little known region of Portuguese East Africa. After enduring with the members of the expedition many hardships, owing to the loss of their ship, and from fever at Delagoa Bay and on the Zambezi, Mr. Griesbach returned to Europe. He published in Vienna, in 1870, "Geologischer Durchschnitt durch Süd-Africa" (Jahrb. geol. Reichs., xx, p. 501); and in the year following, when he came to London, a memoir "On the Geology of Natal in South Africa" (see Quart. Journ. Geol. Soc., 1871, vol. xxvii, pp. 53–71, pls. ii and iii, with 5 text illustrations, a folding coloured geological map of Natal, and a double plate of fossils).

After seven years' residence in London, during which he was engaged in scientific work and drawing, he was, upon the recommendation of Professor Sir Richard Owen, K.C.B., and Dr. Henry Woodward, F.R.S., appointed 26th September, 1878, by the India Office in London, to be an Assistant Superintendent to the Geological Survey of India, and joined in Calcutta the same year. He passed through various grades of promotion in each year from 1880 to 1884.

From November, 1884, to October, 1886, Mr. Griesbach was employed on the Afghan Boundary Commission, with the grade of Deputy Superintendent, and advanced to first grade Superintendent November, 1886. He was created a Companion of the Indian Empire in February, 1887. From 14th January, 1888, to 22nd July, 1889, his services were placed at the disposal of His Highness the Amir of Kabul, made a Superintendent in June, 1889, and became Director of the Geological Survey of India 17th July, 1894, on the retirement of Dr. William King, F.G.S.

When resident in London, Mr. Griesbach served for some years as an officer in the Royal London Militia, now the 6th Battalion Royal Fusiliers, and has since been retired with the rank of Lieut.-Colonel. During his residence in India he was employed on the following War Services, viz.:—

On 6th March, 1880, he was deputed on special service under the orders of the General Commanding Southern Afghanistan; was present at the action of Girishk, 14th July, and the battle of Maiwand, 27th July; attached as Lieutenant to the 66th Regiment, Kandahar Field Force (order No. 271), dated 29th July, 1880; and was present throughout the siege of and battle of Kandahar, 1st September, 1880; favourably mentioned in despatches; received the acknowledgment of the Government of India, also the Medal and Clasp; accompanied the Takht-i-Suliman Expedition, 1883; with the North-Eastern and Irrawaddi Columns 1891–92, Burma Medal and Clasp; Moranzai Expedition, 1892–3.

He was presented with a gold medal by His Majesty the Emperor of Austro-Hungary in recognition of services rendered in connection with the carrying out of the Scientific Expedition in 1892 to the central regions of the Himalayas.

Mr. Griesbach is also an F.R.G.S.; F. As. Soc. Bengal; Foreign Corr. Geol. Soc. Edinb.; Corr. Memb. Verein f. Erdkunde, Leipzig; Corr. M. Ver. f. Erdk. Berlin; Corr. M. k.k. geol. Reichsanst. Vienna; an Hon. Trustee of the Leipzig Museum; and in 1896 was elected a foreign member of the Kais. Akademie d. Wiss. in Vienna.

The following is a list of Mr. Griesbach's scientific papers:—

1.—"Der Jura von St. Veit bei Wien": Jahrb. k.k. geol. Reichsanst., 1868, vol. xviii, p. 123; Verh. do., 1868, p. 54.
2.—"Kössener an Jura Schichten im k.k. Thiergarten bei Wien": Verh. geol. Reichs., 1868, p. 198.
3.—"Die Klippen im Wiener Sandst.": Jahrb. geol. Reichs., 1869, vol. xix, p. 217.
4.—"Die Erdbeben der Jahre 1867 und 1868": Mittheil. der k.k. geograph. Gesell., 1869, vol. xii, p. 195.
5.—"Bemerkungen über die Altersstellung des Wiener Sandst.": Verh. geol. Reichs., 1869, p. 292.
6.—"Geologischer Durchschnitt durch Süd-Africa": Jahrb. geol. Reichs., 1870, xx, p. 501.
7.—"Petrefacten Funde in Süd-Africa": Verh. geol. Reichs., 1870, p. 75.
8.—"On the Geology of Natal in South Africa": Quart. Journ. Geol. Soc., 1871, xxvii, p. 53.
9.—"Geology of the Ramkola and Tatapani Coalfields": Mem. Geol. Surv. Ind., 1880, xv, p. 129.
10.—"Geological Notes (Himalayas)": Records Geol. Surv. Ind., 1880, xiii, p. 83.
11.—"Palæontological Notes on the Lower Trias of the Himalayas": Records, 1880, xiii, p. 94; 1881, xiv, p. 154.
12.—"On the Geology of the Section between the Bolan Pass in Biluchistan and Girishk in South Afghanistan": Mem. Geol. Surv. Ind., 1881, xviii, p. 1.
13.—"Report on the Geology of the Takht-i-Suliman": Records, 1884, xvii, p. 175.
14.—"Afghan Field Notes": Records, 1885, xviii, p. 57.
15.—"Afghan and Persian Field Notes": Rec., 1886, xix, p. 48.
16.—"Field Notes from Afghanistan: No. 3, Turkistan": Rec., 1886, xix, p. 235.
17.—"Field Notes from Afghanistan: No. 4, from Turkistan to India": Rec., 1887, xx, p. 17.
18.—"Field Notes, No. 5, to accompany a geological sketch-map of Afghanistan and North-East Khorassan": Rec., 1887, xx, p. 93.
19.—"Notice of J. B. Mushketoff's Geology of Russian Turkistan": Rec., 1887, xx, p. 123.
20.—"Geological Notes (Spiti Himálayas)": Rec., 1889, xxii, p. 158.
21.—"Geology of the Central Himálayas": Memoirs, 1891, vol. xxiii.
22.—"The Geology of the *Saféd Kóh*": Rec., 1892, xxv, p. 59.
23.—"Geological Sketch of the country North of Bhamo (Burma)": Rec., 1892, xxv, p. 127.
24.—"Notes on the Central Himálayas": Rec., 1893, xxvi, p. 19.
25.—"Notes on the Earthquake in Baluchistán on the 20th December, 1892": Rec., 1893, xxvi, p. 57.
26.—"On the Geology of the country between the Chappar Rift and Harnai in Baluchistan": Rec., 1893, xxvi, p. 113.

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NEW SERIES. DECADE IV. VOL. X.

No. VII.—JULY, 1903.

ORIGINAL ARTICLES.

I.—Notes on Specimens collected by Professor Collie, F.R.S., in the Canadian Rocky Mountains.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

(PLATE XVII.)

THE most interesting series of specimens in this collection comes from Desolation Valley glacier, on the southern side of the Canadian Pacific Railway, and east of the watershed. These are: (1) A roughly pentagonal slab, about 9½″ by 7″ and from ¾″ to 1″ thick, of a rather fine-grained quartzite, with some minute glittering crystals, but giving little or no effervescence with cold HCl. The surface is crowded with wavy cylinders,[1] generally slightly flattened, varying in diameter from about ·55″ to ·15″ (but commonly about ·55″).

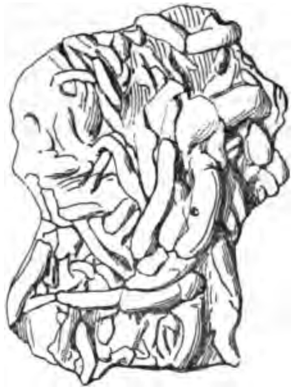

Fig. 1.—Burrows on quartzite slab, about one-third linear of original size.

Externally they are rather smooth, and I think slight indications of a 'shell' can occasionally be detected, perhaps about one-twentieth of an inch thick; others seem to consist wholly of white quartzite, apparently a little purer than that of the underlying slab, but as a rather more flaky yellowish grey material can be detected in the interstices between them they may have been bored in that material.

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[1] The markings in all these specimens, unless expressly stated, are in relief.

(2) Another quartzite slab, roughly oblong, on the average about 5½″ by 4″ and a little thinner, with a slightly more ferruginous coating, has practically identical 'burrows' (Fig. 1). On the underside of each is a rather ferruginous coating or glaze, with some indications of burrows. The material resembles the basal Cambrian quartzite of North-West Scotland in which worm-burrows occur, named *Scolithus*, and figured by Hall,[1] as found there and at the Stiper Stones.[2] Nicholson[3] refers the vertical burrows to one of three genera, *Scolithus*, *Arenicolites*, and *Histioderma*, grouping the more or less horizontal under the name *Planolites* (with three species), which is accepted by Sir J. W. Dawson,[4] who gives a figure from a slab in the Calciferous Sandstone (Tremadoc) of St. Anne's, which appears to be very similar. In the British Museum collection are similar burrows (unnamed) from the same formation, sent by Sir W. E. Logan from the Green Mountains, Vermont. They also resemble the figure of *Planolites* (sp.?) figured by Walcott[5] from the *Olenellus* zone. So I think the burrows on these two slabs may safely be referred to *Planolites*, but shall not venture to suggest a specific name.

(3) Three slabs of a generally similar quartzite are irregular in shape; (*a*) being about 5″ by 4″ and 1½″ thick, (*b*) about 7″ by 3½″, (*c*) about 5″ by 2½″ (both rather thinner slabs). (*a*) has some *Planolites* burrows on an irregularly undulating surface, with four rudely parallel tapering marks, rather over 1″ long, in general form something like a *Pterocera* spine.[6] Similar objects, about seven in number, but in some cases not so well defined, are found on (*b*) (Plate XVII, Fig. 1) with one or two burrow-like marks, but here some are longer, one or two reaching two inches. Both slabs show obscure burrows on their under surface. (*c*) has one of the same (obscure), and near it a small group resembling the markings referred by Sir J. W. Dawson[7] to 'rill-marks,' some obscure worm trails, a bilobed object in relief about 1″ by ⅔″ (Plate XVII, Fig. 2), and possibly the impression of another.[8] It is a pointed oval in shape, with a medial depression, like a grain of wheat, which broadens out so as to produce a flattening at each end. I think the spine-like marks may be the tracks of some rather large Crustacean, though I find neither the corresponding set nor the usual central furrow;

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[1] Geol. New York, vol. i, p. 2, and pl. i.

[2] "Siluria," 4th ed., p. 40. They also recall those figured by Matthew (Proc. and Trans. Roy. Soc. Canada, vol. vii, p. 159, pl. ix) under the name of *Chondrites* from the Cambrian (basal) of Acadia.

[3] Proc. Roy. Soc., vol. xxi (1872–3), p. 288.

[4] Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 612.

[5] Tenth Ann. Rep. U.S. Geol. Surv., pl. lxi.

[6] The form sometimes slightly resembles, though very much larger than, the marks attributed by Salter to *Hymenocaris vermicauda*, Prestwich, Geology, vol. ii, p. 35.

[7] Loc. cit., p. 545.

[8] It has a faint resemblance to the *Rusichnites* of Dawson (loc. cit., p. 597), and to one or two rather similar (but considerably larger) objects in the British Museum collection.

the others may be produced by an animal of the same group, unless they are a peculiar duplication of curving burrows. The underside of the slabs show some ill-marked burrows, and usually the 'glazed' surface already mentioned.

(4) A rather rhomboidal slab of greenish-grey quartzite about 3" by 2" by 1" with a brownish glaze on one surface. On this are little lumps about the size of a small pin's head, four elongated, rudely parallel, slightly curving elevations, somewhat resembling those mentioned above, but barely tapering and so more spine-like; possibly forming part of the same set are three others, which, however, are less regular in shape. On another part of the slab is a single elevation about as thick as a straw, which may be a burrow, and two or three near scarcely thicker than stout pins (once or twice they are in intaglio). Four of these can be detected underlying the first set and crossing them at an angle of about 60°. These are more like burrows, but if so the tendency to be parallel is perplexing. The material of this specimen is more like that of the next one (5), which is a slab rather rhomboidal in outline, measuring about 11" by 5", and roughly 1½" thick (Plate XVII, Fig. 3). From one surface rise a number (about forty) of bosses, dome-like in form, varying in diameter from about ·9" to 1·1", not quite hemispherical, owing to a very slight flattening of the upper part of the dome. A faint ring-like marking, produced occasionally by a slight increase of the radius, but also by a similar decrease, is often perceptible. The majority have a slight depression or dimple at the top (occasionally well-marked), as if made by pressure of a blunt-pointed instrument. In one or two cases the outline of the surface seems traceable into the slab for a short distance. These domes occasionally touch one another, once or twice being very slightly flattened at contact. On the slab also are a few worm-burrows, like those described above, a couple of which seem to end abruptly against the exterior of a dome, about as many pass now and then obliquely over the lower part, and one across the top, where it makes a slight depression. All the domes and burrows are coated by a filmy brownish glaze. The opposite side of the slab consists of a greenish grey, rather flinty argillite, on which at one place is a flattened, slightly raised swelling, about an inch each way, something like a bag in shape, and of slightly different texture. This argillite, in about ¼" or ⅓", passes rapidly into a ferruginous quartzite of which also the mounds consist, but they, together with the burrows, are apparently surrounded by an irregular thin layer of argillite resembling that on the other side.[1] Besides this slab Professor Collie

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[1] By the kindness of Dr. Henry Woodward I have examined the very interesting collection of rock 'freaks' (if such a term be permitted) at the British Museum, but it failed to throw light on these singular structures. They present a certain resemblance to some of the peculiar globular concretions in the magnesian limestone of Durham, which occasionally rise in flattened hemidomes, with a similar slight restriction of the diameter in a horizontal section. But the dents common at the top of the Canadian specimens are wanting, and the latter show no sign of a concretionary structure, which is rare in a sandstone, and so far as I am aware unknown in a quartzite. I find nothing like them in Nathorst's work (Kong. Svenska. Vetenskaps-Akad. Handlingar, xviii, 1881, No. 7), nor in Delgado's Etudes sur les Bilobites, etc.

placed in my hands about half of a mound which had been knocked off its edge, and a fragment of a rather thicker piece of quartzite, slightly paler in colour, on one side of which were two mounds and part of a worm-burrow. I have had a slice cut from the former parallel to the old vertical fracture, and another from the latter in the same direction and practically through the middle of one of the mounds going down about ¾ inch into the quartzite. The two are so similar that one description will suffice. They consist of grains of quartz, a few being sharply angular, the majority subangular, but a fair number rounded, which are sometimes slightly enlarged by a secondary deposit of crystalline silica optically continuous. They exhibit in size and ordering a faint stratification. I find also two or three small grains of a dull brown tourmaline, two of them rather prismatic in outline and one included in a quartz grain. Another slightly more abundant mineral occurs in grains, rather oval in outline, as well as in not very definitely shaped crystalline granules included in quartz grains; these have a high refractive index, are a dull madder-pink or brownish-purple in colour, and are only faintly pleochroic. At first the polarization tints seemed also dull, but a closer study showed that their natural colour masked a real brightness, and the mineral was a dark zircon. One or two grains of a rather granular dull yellow mineral with crystalline outline resemble sphene more than epidote. Grains or granules of an iron oxide, not seldom limonite, are also present, possibly with two or three of a dark ferruginous rutile. All these are scattered in a fairly abundant matrix, which is mainly composed of a minute filmy mica-like mineral, colourless and with fairly high polarization tints, probably a secondary product after felspar, traces of which can here and there be detected. In the larger specimen we find a green filmy or flaky mineral, doubly refracting, barely pleochroic, with rather dull polarization tints, which is probably a variety of chlorite; in the other one there is less of this, but considerably more of a minute, prismatic, fairly dark green mineral, probably an epidote. Thus the microscopic structure, so far from being favourable, is actually adverse to these mounds having a concretionary origin. They cannot, I think, be regarded as casts of a Cœlenterate like a 'jelly-fish' or any other perishable organism. Professor Collie and myself came independently to the conclusion that they could only be casts of pits made by an annelid, as it retreated from the surface. I remember to have seen pits about this size between tide-marks on a beach, some of which (I was told) were made by a *Solen*, others by a lugworm. These casts, so far as size goes, might belong to *Planolites*, with the burrows of which they are associated, but this annelid generally moves horizontally, being thus distinguished from *Scolithus*, which descends vertically. Mr. Walcott, in his "Fauna of the Olenellus Zone,"[1] gives a tube of *Scolithus linearis* leading to the top of a piece of sandstone, where are the casts of three cup-like depressions, and a "summit view of a group of casts of the cup-like depressions" (the latter being sometimes more irregular in outline and not very well drawn), which on the whole are very like the Desolation Valley markings, except that they are barely half the diameter. Murchison, in the figure mentioned above, shows the opening of the burrows to be 'trumpet-shaped,' and Delgado ("Etudes des Bilobites," pl. xxxix, fig. 1) represents *Scolithus* burrows with a saucer-like depression at the top about $\frac{1}{4}''$ in diameter, in the middle of which is a low mamelon about half that width at the base. This would produce a depression in a cast, though much larger in proportion than those in the mounds which I have described, but that difference may be due to something in the material. So I think it very probable these mounds indicate 'pit-holes' formed by the retreat into the mud of *Scolithus* or some annelid of similar habits, and that, as remarked above, the pits were already filled, perhaps a little stiffened, when *Planolites* moved among them, or, in other words, that the pit-making worm lived in the mud and *Planolites* rather in the sand. But more evidence is needed before we can speak confidently on this point.

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[1] Tenth Ann. Rep. U.S. Geol. Surv., p. 603 and pl. lxiii.

From Desolation Valley glacier Professor Collie also obtained four specimens of darkish slaty rock, all probably more or less calcareous, and one which is practically a limestone, not unlike some dark varieties in the British Carboniferous Limestone. Of two other specimens, one has a very pitted surface of a light reddish colour, resembling a compact dolomitic limestone, perhaps with some admixture of sandy material. Professor Collie states that he finds $CaCO_3$ with some $MgCO_3$, and it effervesces but little with cold HCl.[1] The second, whiter in colour, but speckled with dark green (possibly an iron silicate), is a quartzite.

The last specimen brought by Professor Collie contains rounded and subangular pieces, the former being the larger and occasionally nearly one inch in diameter, scattered rather sparsely in a purplish-red calcareous matrix speckled irregularly with the former material, the weathered surface being very rusty. It consists of carbonates of lime and magnesia, with iron oxide. A microscopic examination shows the pale grey enclosures to be a fine-grained dolomitic limestone containing a few granules of quartz or possibly a silicate; the cementing material of the matrix is also a dolomitic carbonate, but is more irregular in its granular structure. In it two kinds of grains are thickly scattered; one being quartz, varying from subangular to well rounded, some of which, at any rate, may be regarded as wind-worn; the other are more variable in shape, enclosed in a dark ferruginous ring, and occasionally almost wholly stained by it. Some have green centres, which show an aggregate structure with crossed nicols, and are probably a variety of glauconite; others resemble the larger fragments, but are a little finer grained; a few apparently retain traces of a reticulate structure (possibly crinoidal); two or three thin elongated or curved objects may be fragments of mollusca, and one suggests a spiral foraminifer.

There is no precise evidence as to the age of any of these

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[1] The chemical notes throughout are the results of Professor Collie's qualitative examinations.

Desolation Valley specimens. Worm burrows and tracks are not very helpful, but *Planolites* appear to be commonly found in rocks belonging to the Cambrian period, ranging from the bottom to the top. Lithological character also is not the safest of guides, but I may remark that both the white quartzites and the slabs with the mounds remind me of Cambrian rocks, the former being not unlike the basal quartzite of Britain, and the matrix of the latter being more altered than is usual in a rock belonging even to the later part of the Cambrian. So I think we may pronounce the quartzites and argillites from Desolation Valley to be not more modern than Lower Cambrian, the limestones probably belonging to a later part of the Palæozoic.

Mount Neptuak (10,500 feet) rises at the head of Desolation Valley glacier, on the watershed between the Bow and the Vermillion Rivers, about 12 miles in a direct line from Hector Pass. A specimen "from the ridge" is a limestone ($CaCO_3$, with a little $MgCO_3$, a very small amount of insoluble residue, and some carbonaceous matter). In colour it is a pale brownish grey, mottled rather irregularly, and in about equal quantities with a darker shade of the same. The microscope shows it to be a very fine-grained dolomitic limestone, mottled by another rather more coarse, its grains varying about ·005 inch in diameter. The finer part is once or twice traversed by a sharply zigzagged dark line suggestive of fracture, and the coarser seems to run up into a crack in the finer material, the latter corresponding with the darker parts of the rock; it also contains a few thin fragments, straight, or hooked, or more or less oval, probably organic, perhaps molluscan. I suspect that the finer-grained rock has been brecciated *in situ* and subsequently cemented by infiltration.

The remaining specimens come from the northern side of the Canada Pacific Railway, and at a much greater distance from it. Mount Freshfield (about 10,900 feet) is on the watershed where it has bent much to the west. It drains on one side to the Bush River (South Fork), on the other to the Blaeberry Creek, which joins the Columbia River. From the Freshfield Glacier comes a pebble, possibly a rather crushed and decomposed diabase, containing perhaps a speck of sodalite. From near the summit of the mountain are two limestones, each rather curiously marked, one being yellowish ($CaCO_3$ with a little SiO_2), indicating, I think, local brecciation and recementation; the other (yielding a white residue and no MgO) possibly due to a similar cause. They have a general resemblance to later Palæozoic limestones.

A specimen from the Bush Pass near Mount Freshfield is an impure limestone ($CaCO_3$ with MgO, and some SiO_2 or Al_2O_3); it affords dubious traces of organisms and may be Palæozoic.[1]

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[1] In 1900 Professor Collie (Geogr. Journ., xvii, 1901, p. 268) brought a few specimens from pebbles in the bed of the Bush River, some distance away to the west. One is a limestone with oolitic grains recrystallized; another contains fragments of organisms, ill preserved; two show a coral which, according to Mr. E. T. Newton, F.R.S., probably in one case, certainly in the other, belongs to the genus *Diphyphyllum*.

A specimen from a "washout beneath Forbes," at the junction of the stream from the Freshfield Glacier with the valley from Bush Pass, which runs ultimately into the Saskatchewan River, is a black cherty-looking rock, harder than the knife (insoluble in HCl, but with faint traces of $CaCO_3$). This, under the microscope, exhibits rather more minute granules and rhombs of a carbonate (probably dolomite) than I should have anticipated; its general colour being a very pale brown. The slice is crowded with small clear organisms, about ·005 inch in length, sometimes cylindrical, which on examination with a high power prove to be siliceous. The material is occasionally doubtfully colloid, more often of minute crystalline granules, with occasional local replacement by calcite or dolomite. Believing these to be sponge spicules, I submitted the slice to Dr. G. J. Hinde, F.R.S., to whom I am indebted for the following note: "These are rod-like bodies, showing traces of an axial canal, which I feel certain are sponge spicules, and I should also refer the confused mass of fragmentary rods to spicules, but they are now so much altered that it is impossible to recognize if any of them belong to lithistids" [I had suggested the possibility]. He adds: "I have a slice of chert or cherty limestone from the Durness Limestone of Sutherland which is not unlike your section, but the spicules are more distinct and the rhombs of calcite or dolomite less crowded than in the Canadian rock." The slice is traversed by wavy dark-brown lines (? infiltrated cracks).

The specimen from a peak south-east of Mount Lyell and west of Mount Sullivan, at the head of the Valley of the Lakes (which drains to the North Fork of the Saskatchewan), is a calcareous conglomerate ($CaCO_3$, no MgO), consisting of rather flat, subangular to rounded fragments, none exceeding ·75 inch, of a pale grey compact limestone in a yellowish calcareous matrix. Examination with the microscope shows the fragments to be varieties of a limestone, generally slightly dirty in aspect, occasionally a little speckled with a dark brown (? bituminous) material, and crowded with minute fragments of organisms (not to be identified with certainty) and small round grey spots (about ·0025 inch in diameter), probably oolitic. There are also a few small grains of quartz. The matrix is more or less stained with limonite, contains many fragments of organisms, similar but larger; some showing traces of prismatic structure, and probably molluscan; some perhaps Brachiopods; some also possibly calcareous sponge spicules.

Mount Forbes (about 12,000 feet) is also to the south-east of Mount Lyell, but to the south of Mount Sullivan. A specimen from near the summit is a dark limestone, containing MgO as well as CaO, not unlike some British Carboniferous limestones.

Mount Howse (about 10,800 feet) is in the same district, but to the E.S.E. of the last peak, and on the watershed, where it suddenly changes from a N.N.W. direction to a south-west one. The summit is a compact darkish grey limestone (mostly $CaCO_3$, with a little $MgCO_3$ and a blackish residue after solution in HCl) with one or two small white enclosures, and a few thin veins of calcite, weathering with a rather irregular, lumpy surface. Examination under the microscope shows it to be a rather fine-grained limestone, slightly discoloured (probably by a bituminous material which may be also represented by a few scattered granules). The veins and enclosures are a coarser calcite, especially the latter, in which the grains are about as large as in ordinary crystalline limestones. No organisms are recognizable.

From Mount Noyes (10,000 feet), about 5 miles east of Mount Howse, we have the following specimens:—(1) A dark limestone (picked up on a glacier) resembling some British specimens from the Carboniferous system, and containing a silicified coral like a Lithostrotion. The fossil is not well preserved, but Mr. E. T. Newton, F.R.S., who has kindly examined it, tells me he is almost certain it belongs to the genus *Diphyphyllum*, which, as he remarks, leaves the age uncertain, as it has been found in both the Carboniferous and the Silurian. (2) A darkish limestone with damaged trilobites, in regard to which Dr. H. Woodward kindly furnishes the note appended to this paper.[1] (3) The summit rock is an impure limestone ($Ca\,C\,O_3$, with traces of $Mg\,O$ and a good deal of insoluble residue), with some small irregularly rounded enclosures, which may be either fragments or casts of bivalves, but on the whole I incline to the view that the rock retains traces of organisms. It has a general resemblance to later Palæozoic limestones in Britain.

From the Canyon of the Bear Creek, which runs between Mounts Howse and Noyes, comes a dark limestone ($Ca\ Mg\ C\ O_3$), with nothing about it to suggest the possibility of ascertaining a date.

Mount Murchison (11,100) lies roughly east of Mount Lyell, and well to the east of the watershed between Bear Creek and the Saskatchewan River.[2] The summit is a pisolitic limestone ($Ca\,C\,O_3$ with a little $Mg\,C\,O_3$); oblately spheroidal bodies in diameter from half an inch downwards, of a darkish grey colour, indicating on weathered surfaces a concentric structure, being set in a light yellowish or brownish matrix. The pisolites under the microscope consist of a rather muddy limestone containing a few specks of quartz or a silicate, also brown granules and possibly a very few fragments of small organisms. They exhibit a rough concentric, but no radial structure, and in one or two places something resembling a minute branching suggests traces of *Girvanella*. In the matrix, which is not very different, except that it consists of larger and more translucent grains, we find granules (? bituminous), a few quartz grains, one or two of which show a crystalline outline, oolitic grains with traces of radial structure, often having small fragments of an organism as a nucleus, and several bits of shell, most of them probably bivalves, but one or two possibly Gasteropods. In one case the structure resembles that of an echinoderm (? crinoid).

Mount Hector, which is about ten miles from the pass of that name, and on the eastern side of the watershed (being almost north

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[1] Professor Collie informs me that it was found "just above the bands of Cambrian quartzite, the same as occurs on Mount Hector and elsewhere."

[2] It is some ten miles N.N.W. of Mount Noyes.

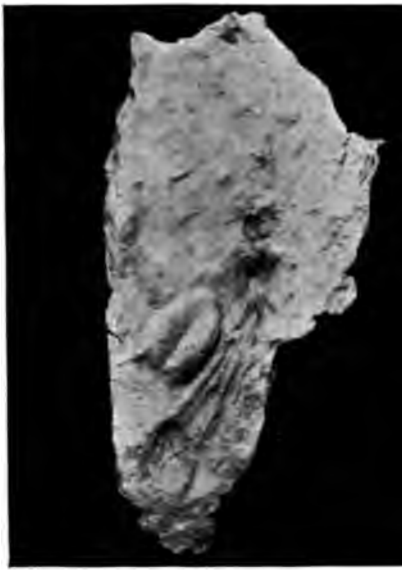

FIG 2.

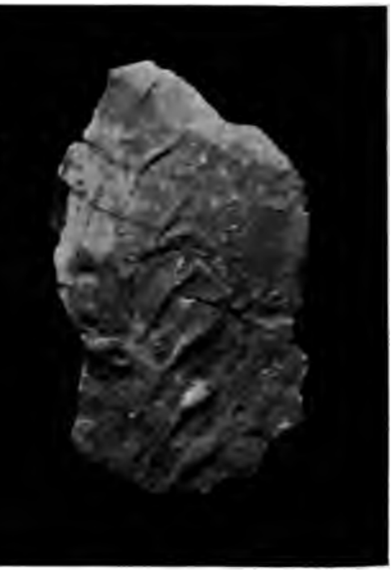

FIG. 1.

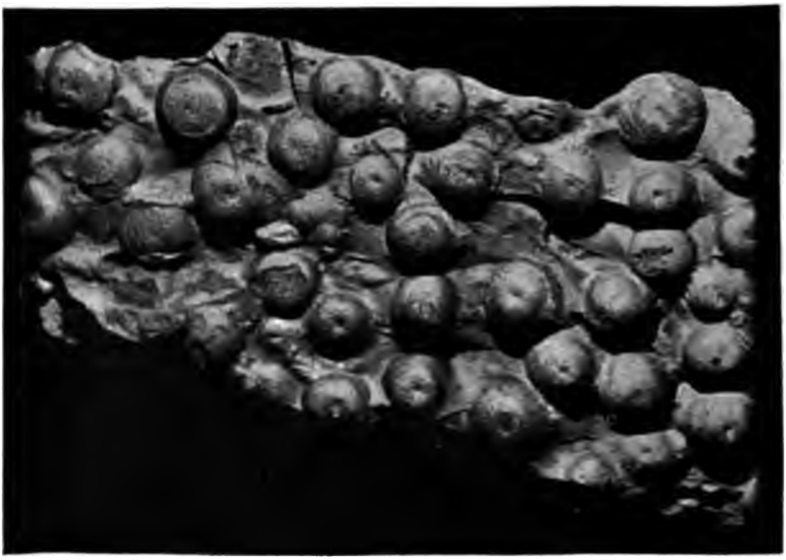

FIG. 3.

·kings on Quartzite Slabs from the Canadian Rocky Mountains.

of Laggan), is represented by a light-coloured fine-grained quartzite, which was collected from directly below the summit and on its western side. It might very well be from one of the older Palæozoics.

In Professor Collie's collection, as in that made by Mr. Whymper, well-preserved organisms are rare.[1] Several of the limestones in the former are in the same mineral condition as those described from the latter one, so that it seemed needless to have them sliced, and I may refer to what I have already said.[2] No doubt a closer search will discover occasional localities with well-preserved fossils such as that on Mount Stephen, but I anticipate that in this part of the Rocky Mountains (nearly 60 miles in length), as in some of the Alps, there will be considerable districts of sedimentary rock in which fossils are absent or barely recognizable.

EXPLANATION OF PLATE XVII.

Fig. 1.—Slab of quartzite, with spine-shaped markings. About 7 inches by 3½ inches.

Fig. 2.—Slab of quartzite, with bilobed marking. About 5 inches by 2½ inches (broader part).

Fig. 3.—Slab of quartzite, with mounds. A very little has been excluded from each end of the block in taking the photograph. It is about one-third linear of the original.

(Fig. 3 by permission of the Royal Geographical Society.)

Note on some Fragmentary Remains of Fossils from the upper part of Mount Noyes (Canadian Rockies). By H. Woodward, LL.D., F.R.S.—The specimens (reproduced in the accompanying diagram about twice natural size) lie scattered over the weathered surface of a thin and somewhat worn, hard, black, slaty rock, in character not unlike that so rich in Trilobites from Mount Stephen (B.C), (see Geol. Mag., 1902, Dec. IV, Vol. IX, pp. 502–505). After much hesitation, on account of the imperfect nature of the materials at my disposal, I venture, with some reserve, provisionally to place these remains as follows:—

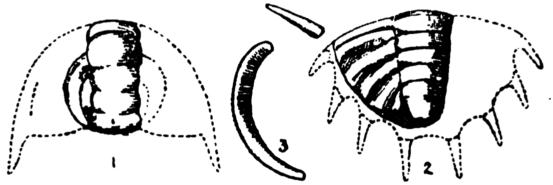

Fig. 1.—*Olenellus ? Thompsoni*, Hall: Bull. U.S. Geol. Surv., No. 30 (1886), p. 167. Walcott, Olenellus Zone: 10th Rep. U.S. Geol. Surv., 1889, p. 635, pl. lxxxii, figs. 1, 1*a*; pl. lxxxiii, figs. 1, 1*a*, *b*. A glabella with four pairs of furrows, a raised and rounded anterior border, one fixed cheek, and indication of the left eye and cheek are also seen upon the surface of the slab. A fragment of another head is present, but is too imperfectly preserved for determination.

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[1] For the exceptions see Dr. H. Woodward's paper in last year's volume of this Magazine, p. 502. My report will be found at p. 544.

[2] Ibid., p. 549.

FIG. 2.—*Olenoides*, sp.? Walcott, Fauna of the Lower Cambrian or Olenellus Zone: 10th Rep. U.S. Geol. Surv., 1899, p. 752, etc., pl. xciv, fig. 1. This genus is represented by an imperfect pygidium, in size equalling *Olenoides Fordi*, Walcott. The border is wanting, but a single spine lies near the left anterior margin, which may have been a marginal spine of the pygidium or a detached median spine.

FIG. 3.—*Helenia bella*, Walcott. Two or three elongate, narrow, flattened, curved tubes may be seen upon the surface of the same slab, one of which is reproduced in Fig. 3. It resembles a specimen figured by C. D. Walcott (Fauna of the Olenellus Zone: 10th Ann. Rep. U.S. Geol. Survey, 1889, pl. lxxviii, fig. 4), which he names *Helenia bella* and refers provisionally to the Dentalidæ.

II.—NOTES ON OCEAN ISLAND (BANABA).

By F. R. COWPER REED, M.A., F.G.S.

OCEAN ISLAND, which is also known as Banaba or Paanopa, lies in the Pacific west of the Gilbert group, in lat. 0° 52′ S., long. 169° 35′ E. Our knowledge of it is but scanty; Darwin[1] briefly mentioned it, and it is not the same Ocean Island as Dana[2] described, for the latter lies in lat. 28° 25′ N. and long. 178° 25′ W. It may be therefore of some interest to record a few notes on a small collection of specimens of phosphatic and coral rocks made on it by Capt. R. Tupper, R.N., of H.M.S. "Pylades," who hoisted the British flag there in the year 1900. I am also indebted to him for a description of the island, and to the Pacific Islands Company, Ltd., for kindly furnishing me with further particulars of its physical features and analyses of the phosphatic rocks.

The island is of subcircular shape, with a circumference of about six miles at high-water mark; along its southern side there is a shallow concavity known as Home Bay, bounded on the west by Lilian Point, and on the east by the longer and more prominent headland known as Sidney Point. Except along a small portion of this bay the island is surrounded by cliffs from 12 to 30 feet high, and soundings show that very deep water extends close up to them. The interior forms an elevated tableland rising to a height of about 260–270 feet, with a few surface depressions. The whole island consists entirely of coral formation, and is covered with extensive phosphatic deposits worked by the above-mentioned company. The coral-rock is much weathered, rising in places into high pinnacles and prominent masses of peculiar shapes, and is seamed by deep gullies and fissures in which the phosphatic deposits attain their greatest thickness. A boring of 29 feet in one place failed to pierce them. It is stated that there is a sharp line of demarcation between the phosphatic material and the underlying coral-rock, but some of the specimens submitted to me show that the former has infiltrated and impregnated the latter. The rocks are in many cases of detrital origin, being composed of fragments of calcareous rocks cemented together into a more or less compact mass. One specimen is a coarse breccia; another is an irregular conglomerate of rounded or subangular fragments or grains of various shapes and sizes. Recognisable remains of organisms are very rare, but under the microscope a few fragmentary foraminiferal shells can be distinguished in a thin section. The cementing material is a hard pale yellowish or brownish substance of a semi-translucent and resinous appearance, which encases the fragments and lines or more or less fills up the interstices between them. In one specimen the grains are of fairly regular size, and represent a coral sand, converted into a fine oolite by each grain being surrounded by concentric coats of the same cement, and the whole mass thus bound into a solid and compact rock which rings under the hammer. Under crossed nicols a thin section shows that the coats consist of a series of regular concentric layers with a fibrous radial structure, like Renard[1] has described in the oolitic calcareous rocks of Ascension Island. In these examples from Ocean Island we find all degrees of coarseness in the oolitic structure—from a coarse pisolite to a very fine oolite; and in some specimens the cementing material is in excess of the included grains and forms the mass of the rock, losing then its radial structure and behaving under the microscope as an almost isotropic groundmass. The cement in all cases effervesces scarcely at all or but feebly with acid, and is of a phosphatic nature. A completely different type of phosphatic rock consists of regular narrow bands of a yellowish or brownish substance of a semi-translucent resinous appearance. This agate-like rock is very tough and heavy, and has a sub-conchoidal fracture. It seems to consist entirely of the cementing phosphatic material found in the above-mentioned oolites, and behaves in a similar fashion with acids.

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[1] Darwin: "Coral Reefs," 3rd ed., 1889, p. 217.

[2] Dana: "Corals and Coral Islands," 3rd ed., 1890, p. 361.

One mass of coral (*Mæandrina*) is encrusted with stalactitic deposits of the brownish phosphate which surrounds the corallites, and has more or less obliterated their structure round the margins. Irregular mammillary or stalactitic forms of the phosphate are also met with, and sometimes they enclose patches of fine soft calcareous mud with a hard porcellanous fibrous coating of a bluish or buff colour. One specimen seems to represent the soft calcareous mud of the ancient lagoon, and it now forms a tough fine-grained chalky limestone of a white or buff colour with a conchoidal fracture. Under the microscope minute irregular fragments or broken prisms of calcite are seen to be scattered through it. In another specimen this consolidated mud is banded by brownish layers of a homogeneous opaque substance, not effervescing in the least with acids, and apparently representing original layers of deposition. A fragment of calcareous tufa with the typical arborescent and cavernous structure is present in the collection, but it has a hard brownish phosphatic crust.

The detailed distribution and relations of these various types of rocks have not been studied, and I have no precise information as to their mode of occurrence. The guano which has led to the formation of the phosphates on Ocean Island is no longer being deposited there, but at what period it ceased is a matter of speculation, though the present condition of the deposits suggests that a considerable time must have elapsed. On many other islands in the dry central parts of the Pacific, such as Howland's, Jarvis', Baker's, and Malden's Islands, guano deposits occur and are still forming, as Dana[1] and others[2] have described.

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[1] Renard: "Challenger" Reports, Physics and Chemistry, vol. ii, Rep. Rocks, p. 71.

By the courtesy of the Pacific Islands Company, Ltd., in furnishing me with Dr. Voelcker's analyses of the phosphates of Ocean Island, I am able to state that representative samples show an average of 86·57 phosphate of lime, 2·26 carbonate of lime, 0·21 oxide of iron, and 0·31 alumina.

A complete analysis by Dr. Voelcker of one sample of "hard rock," exported as phosphate, is as follows:—

Organic matter and combined water	1·30
Phosphoric acid	39·53
Lime	52·54
Oxide of iron	·15
Alumina	·26
Magnesia, etc.	4·50
Carbonic acid	1·62
Insoluble siliceous matter	·10

(Sample dried at 100° C.)

The coral-rocks and phosphates of Christmas Island, which Dr. C. W. Andrews has kindly allowed me to examine, appear to be of a different character to those from Ocean Island. Mr. J. Stanley Gardiner, M.A., has kindly examined the two fragmentary corals in the collection presented to us, and has identified them as belonging to the genera *Mæandrina*, E. & H. (? subgen. *Cœloria*, E. & H.), and *Orbicella*, which he states are both widely distributed in the Pacific at the present day, and are among the most important of the reef-builders.

III.—On some *Isochilinæ* from Canada and elsewhere in North America.

By Professor T. Rupert Jones, F.R.S., F.G.S.

Among a large number of Canadian fossils sent to me by Col. C. C. Grant, of Hamilton, Ontario, for transmission to the British Museum (Natural History Branch), there were three particular specimens of fossiliferous limestone worthy of careful examination. These came from a glacial drift at Hamilton, known as 'Bala Drift.' There being no real 'Bala' strata in Canada, the appellation of 'Bala Drift' at Hamilton applies to a glacial drift containing fossils more or less allied to those of *Bala*, most probably to the Trenton Limestone, a Lower Silurian (or Ordovician) formation.

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[1] Dana: "Corals and Coral Islands," 3rd ed., 1890, pp. 318–324.

[2] Hague: Amer. Journ. Sci., ser. II, vol. xxxiv (1862), p. 224. Julien: ibid., vol. xl (1865), p. 367.

I. *Isochilina gregaria* (Whitfield), var. *Ulrichiana*, nov. (Figs. 1*a*–*b*.)

No. 1 is a specimen of fine-grained, compact, grey-blue limestone, retaining part of the smooth surface of a suboval pebble, perhaps originally about four inches long. The broken surface (of the split? pebble) shows one good example and two smaller indications of a smooth, black, and shiny species of *Isochilina*, which I regard as a modification of *I. gregaria* (Whitfield), Bull. Amer. Mus. Nat. Hist., vol. ii, p. 58, pl. xiii, fig. 3.

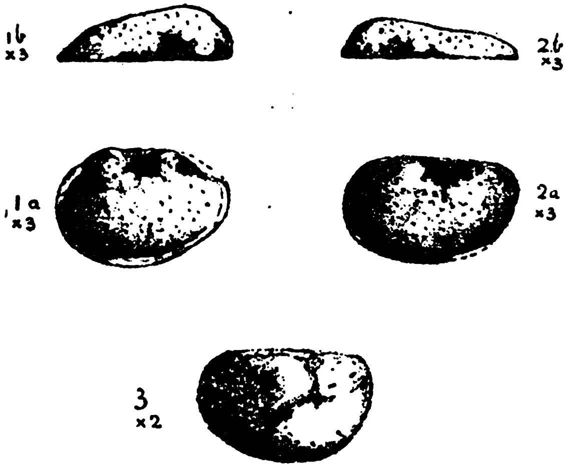

Fig. 1.—*Isochilina gregaria* (Whitfield), var. *Ulrichiana*, nov. (*a*) Right-hand valve. (*b*) Dorsal edge. Magnified 3 diam.
Figs. 2*a*, *b*.—Another specimen of the same. Magnified 3 diam.
Fig. 3.—*Isochilina* sp., ind. Crushed. Magnified 2 diam.
Figs. 1–3 from a drifted (Trenton?) limestone at Hamilton, Ontario.

It is an imbedded bivalved carapace, showing its dextral valve, ovate-oblong, narrower and more convex in front than behind.[1] Marginal rim strong on the posterior, ventral, and anterior borders. Surface black, smooth, shiny, and very delicately punctate. It has a broad mid-dorsal depression (nuchal notch), bordered by a low semicircular ridge, composed of four tubercles of irregular size; the two largest touch the dorsal edge, and are united below by one round and two oblong smaller tubercles.

This nuchal sulcus approximates in the pattern of its border to that in *Isochilina gregaria* (Whitfield).

The length of the valve is 8 mm., height 6 mm. It is in the specimen No. 1, 'Bala Drift,' Hamilton, Ontario.

I*a*. *Isochilina gregaria* (Whitfield), var. *Ulrichiana*, nov. (Figs. 2*a*–*b*.)

No. 2 specimen is a piece of limestone similar to that of No. 1, but darker. One face appears to have been artificially flattened and smoothed; and the other presents a broken surface, showing one good Ostracod valve, like that of No. 1, but smaller, together with two still smaller, but allied, specimens, and some indeterminable fragments.

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[1] This anterior convexity is unusual.

Smaller than Fig. 1, and of similar outline, but with less protrusive postero-ventral curvature, and more convexity in the posterior moiety of the surface of the valve. Differences in the superficial convexity of *Isochilinæ* are shown in figs. 1–6 of Professor Whitfield's pl. xiii, 1889.

The tubercular border of the nuchal notch partly remains, one tubercle on one side and two on the other.

Length 8 mm., height 5 mm. In specimen No. 2, 'Bala Drift,' Hamilton, Ontario.

II. *Isochilina gregaria* (Whitfield), var. (?).

Small bivalved carapace, much like Nos. I and I*a* in shape, subovate, convex in the middle of the valve.

Length 3½ mm., height 2 mm.

III. *Isochilina*, sp.? (Fig. 3.)

No. 3 is a limestone similar to that of No. 2, but coarser and evidently full of organic fragments. One surface is flat and smooth, probably the natural surface of a glaciated rock. The other face exhibits an internal cast of an Ostracod valve, probably an *Isochilina*, somewhat distorted by pressure. Among the accompanying obscure little organisms is a small *Beyrichia* (?) or *Tetradella*.

This cast of a somewhat crushed valve is larger than either Nos. I or I*a*; suboblong, with marginal rim; surface somewhat undulating, having been distorted by pressure. Depressed across the hinder moiety of the valve with a gentle curve. An obscure indication of the base of a broken spine near the posterior margin.

Length 10 mm., height 7 mm. 'Bala Drift,' Lake Shore, Winona, Ontario.

IV. *Tetradella* (?), sp.

The little Beyrichian (?) individual (length 2 mm., height 1½ mm.) on the specimen No. 3, 'Bala Drift,' Lake Shore, Winona, Ontario, with its narrow lobes, although obscure, bears evidence of having a long semicircular thin ridge along the ventral region, just within the ventral border, giving rise apparently to three ridges stretching across the central area towards the dorsal edge. This form may be said to be allied to *Beyrichia Marchica*, Krause,[1] and *Beyrichia Busseacensis*, Jones,[2] and more particularly to E. O. Ulrich's *Tetradella subquadrata*, Journ. Cincin. Soc. Nat. Hist., vol. xiii, pt. 1 (1890), p. 115, fig. 2. All of them belong to the Lower Silurian series.

Some Lower Silurian (probably Chazy) specimens from Ottawa (Ontario), Canada, were referred to in the Quart. Journ. Geol. Soc., vol. xlvi (1890), pp. 545, 550, and 551, as *Isochilina Ottawa*, Jones.[1] Variety, (1) occurring abundantly on the bed-planes of a piece of thin-bedded limestone, from a large block in Sussex Street, Ottawa, and probably belonging to the Chazy formation (upper portion); (2) constituting, with a few bivalve Mollusca, the greater part of an easily broken grey limestone from Nepean, Ontario, Canada, belonging to the Chazy formation. Both were sent from Canada by Mr. Henry M. Ami, F.G.S., of the Canadian Geological Survey.

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[1] Zeit. d. D. Geol. Ges., 1889, p. 19, pl. ii, figs. 9–11.

[2] Quart. Journ. Geol. Soc., vol. ix (1853), p. 160, pl. vii, figs. 5 and 6; and Biv. Entom. Geol. Assoc., 1869, p. 15, figs. 23*a*–*b*.

We have to note that the specimens of *Isochilina Amiana* and its variety *insignis*, described by Mr. E. O. Ulrich in the Journ. Cincin. Soc. Nat. Hist., 1891, pp. 180 and 181, pl. xi, figs. 12*a–c* and 13, were also derived from a piece of Chazy rock found by Mr. H. M. Ami in Sussex Street, Ottawa, and given by him to Mr. Ulrich; and they are therefore from the same source as that of the variety of *I. Ottawa* mentioned above. It was carefully illustrated as var. *intermedia* in the Contrib. Canada Micropal., part iv (1891), pl. x, figs. 10*a–b*, 11*a–b*, and a copy of this plate had been forwarded to Mr. Ulrich, as explained in the footnote at p. 181 of his memoir above mentioned. Mr. Ulrich was satisfied, according to that footnote, that the figures named by me *Isochilina Ottawa*, var. *intermedia*, must have been drawn from such specimens as his *I. Amiana*; indeed, both came from Mr. Ami, of Ottawa, as fully explained.

The Ostracoda in the hand-specimens from Hamilton, Nos. 1 and 2, very definitely represent the group of *Isochilinæ* allied to *I. Ottawa* and *I. gracilis*, enumerated in the following catalogue of the known *Isochilinæ*, many of these being either allies, subspecies, varieties, or mutations of *I. Ottawa*, especially those marked "1–13," the many minor differential features being rarely sufficient to separate them specifically.

CATALOGUE OF THE KNOWN *ISOCHILINÆ*.

1856. *Leperditia margineta* (?), Keyserling [afterwards *Isochilina grandis*, Jones]: Ann. Mag. Nat. Hist., ser. II, vol. xvii, p. 91, pl. vii, figs. 14*a–d*.

(1) 1858. *Leperditia* (subgenus *Isochilina*) *Ottawa*, sp. nov.: Ann. Mag. Nat. Hist., ser. III, vol. i, p. 248, pl. x, figs. 1*a–c*. Calciferous Sandrock, Grenville, Canada. And Geol. Surv. Canada, Org. Rem., 1858, p. 97, pl. xi, figs. 14*a–c*.

(2) 1858. *Leperditia* (subgenus *Isochilina*) *gracilis*, sp. nov.: ibid., figs. 2*a–d*. White House Papers. Trenton Limestone or Bird's Eye Limestone: Isle Jesus, Canada. And Ann. Geol. Surv. Canada, Org. Rem., 1858, p. 98, pl. xi, figs. 15*a–d*.

(3) 1860. *Isochilina gracilis*, Jones: Month. Microsc. Journ., vol. iv, pp. 185 and 191, pl. lxi, figs. 18*a–c*. Lower Silurian: Canada.

1881. *Isochilina grandis*, Jones [*non* Schrenck]: Ann. Mag. Nat. Hist., ser. v, vol. viii, p. 347.

1881. *Isochilina Jonesi*, Wetherby: Journ. Cincin. Soc. Nat. Hist., vol. iv, p. 42, pl. ii, figs. 7 and 7*a*. Trenton Limestone: Kentucky.

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[1] Ann. Mag. Nat. Hist., April, 1858, p. 248, pl. x, fig. 1—not so well figured there as on later occasions.

1883. *Leperditia (Isochilina) armata*, Walcott: 35th Report N.Y. State Museum Nat. Hist., p. 7, pl. xvii, fig. 10. Bird's Eye and Black River Limestones: Herkimer Co., N.Y.

(4) 1884. *Isochilina Ottawa*, Jones: Ann. Nat. Hist., ser. v, vol. xiv, p. 345. Chazy Limestone, 5 miles west of L'Orignal, and Calciferous Sandrock, Grenville.

(5) 1889. *Primitia (Isochilina) gregaria*, Whitfield: Bull. Amer. Mus. Nat. Hist., vol. ii, p. 58, pl. xiii, figs. 3–5. Calciferous formation: Cave Island, Ball's Bay, Vermont, Lake Champlain.

(6) 1889. *Primitia (Isochilina) cristata*, Whitfield: ibid., p. 59, pl. xiii, figs. 1 and 2. With the foregoing.

1889. *Primitia (Isochilina) Seelyi*, Whitfield: ibid., p. 60, pl. xiii, fig. 6. Limestone: Shoreham, Vt., and Providence Island, Lake Champlain.

1890. *Isochilina lineata*, Jones: Quart. Journ. Geol. Soc., vol. xlvi, p. 21, pl. ii, figs. 5*a*–*b*, 6*a*–*b*. Hamilton Group: N.Y. State.

1890. *Isochilina (?) fabacea*, Jones: ibid., p. 22, pl. ii, fig. 11. Hamilton Group: Lake Erie, N.Y.

1890. *Isochilina Seelyi* (Whitfield), Jones: ibid., p. 22, pl. i, fig. 7. Bird's Eye Limestone (?): Shoreham, Vermont, and Providence Island, Lake Champlain.

(7) 1890. *Isochilina gregaria* (Whitfield), Jones: ibid., p. 22, pl. i, figs. 9 and 10. Calciferous Sandrock formation: Cave Island, Ball's Bay, Lake Champlain, Vermont.

(8) 1890. *Isochilina cristata* (Whitfield), Jones: ibid., p. 23, pl. i, fig. 8. Cave Island, as above.

(9) 1890. *Isochilina* (?), sp., Jones: ibid., p. 23, pl. i, fig. 15. Cave Island, as above.

1891. *Isochilina grandis*, Jones, var. *latimarginata*: Contrib. Micropal. Canad., 1891, p. 78, pl. x, figs. 1–4. Silurian: Manitoba and Saskatchewan.

(10) 1891. *Isochilina Ottawa*, Jones, var. *intermedia*, nov.: ibid., p. 66,[1] pl. x, figs. 10, 11. Chazy to Lower Silurian or Cambro-Silurian.

1891. *Isochilina Whiteavesii*, nov.: ibid., p. 68, pl. x, fig. 13. Trenton Limestone, Lorette.

1891. *Isochilina Amii*, nov.: ibid., p. 68, pl. x, fig. 14. Trenton Limestone, Lorette.

1891. *Isochilina labellosa*, nov.: ibid., p. 69, pl. x, fig. 19. Chazy Series, Aylmer, Quebec, and Bird's Eye and Black River Limestones, Carleton, Ontario.

1891. *Isochilina subnodosa*, Ulrich: Journ. Cincin. Soc. Nat. Hist., vol. xiii, p. 177, pl. xi, figs. 7*a*–*c*. Upper Trenton Limestone: Perryville, Kentucky.

1891. *Isochilina Saffordi*, Ulrich: ibid., p. 178, pl. xi, figs. 10*a*–*d*. Upper Trenton Limestone: Nashville, Tennessee.

1891. *Isochilina ampla*, Ulrich: ibid., p. 179, pl. xi, figs. 8*a*–*d*. Upper Trenton Limestone: Nashville, Tennessee.

1891. *Isochilina Jonesi*, Wetherby: Ulrich, ibid., p. 179, pl. xi, figs. 9*a*–*c*. Upper Trenton Limestone: Harrodsburg, Kentucky.

1891. *Isochilina Kentuckyensis*, Ulrich: ibid., p. 179, pl. xi, figs. 11*a*–*d*. Upper Bird's Eye Limestone: Kentucky.

(11 & 12) 1891. *Isochilina Amiana*, Ulrich: ibid., p. 180,[2] pl. xi, figs. 12*a*–*c*; and var. *insignis*, Ulrich, p. 181, pl. xi, fig. 13. Upper Chazy (?): Ottawa, Canada.

(13) 1903. *Isochilina gregaria* (Whitfield), var. *Ulrichiana*. Figs. 1 and 2 in this paper. Trenton (?) formation, in Glacial Drift, Hamilton, Ontario.

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[1] The definition of varieties is carefully given at p. 67, and the localities enumerated.

[2] Footnote at p. 181: "Since the above was written I have received from Professor T. Rupert Jones proofs of the plates which have been prepared for the Geological Survey of Canada. On plate x I notice figs. 10*a* and 11*a*, because I am satisfied that they have been drawn from specimens of *I. Amiana*. These figures are marked '*I. Ottawa* variety,' but for the reasons stated above I cannot accept this [illegible]tion for my specimens."

IV.—The Circular Form of Mountain Chains.

By Philip Lake, M.A., F.G.S.

I AM a stranger in the field of speculation, and am quite unacquainted with the intricacies of its authorized boundaries. It is therefore with some hesitation, lest I should tread upon forbidden ground, that I venture to offer a suggestion on one point in Professor Sollas's paper on "The Figure of the Earth."[1]

It has long been observed that mountain ranges and chains of islands (which, indeed, are only mountain ranges partially submerged) are generally curvilinear in form, but Professor Sollas is, I believe, the first to show clearly that the curve often coincides almost exactly with an arc of a circle. Such a mountain chain is frequently defined along its convex margin by a great reversed fault over which the mountain mass has slid forward; and in these cases, at least, we may safely adopt Suess's conception, and look upon the chain as the crumpled edge of a 'scale' of the earth's crust which has been pushed forward over the part in front of it.[2] The surface along which the movement has taken place is called a thrust-plane. If this surface really is a plane, then the edge of the 'scale,' that is the mountain chain itself, must necessarily be circular in form; for if any plane cuts a sphere, in any position whatever, the outcrop of the plane on the surface of the sphere will always be a circle. There can be no deviation from the circular form unless the 'sphere' is not truly spherical, or the 'thrust-plane' is not a true plane. On the scale of an ordinary globe the earth is sensibly a sphere, and therefore any deviation which is visible on such a globe must be produced by a deviation of the surface of movement from a true plane.

Further, in the case of a circular mountain range it is possible from the form of the arc to determine the dip of the basal thrust-plane; for it is easy to show that the angle which a plane makes (at its outcrop) with the surface of the sphere is equal to the angular distance, measured on the surface of the sphere, between the centre and the circumference of the circle formed by the outcrop of the plane.[3]

Thus, for example, the centre of the Himalayan arc is placed by Professor Sollas in lat. 42° N. and long. 90° E., and the angular distance from this point to the arc is 14°. This, then, is the angle which the basal thrust-plane must make with the surface at its outcrop.

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[1] Quart. Journ. Geol. Soc., 1903, p. 180.

[2] The very beautiful sections of the outer Himalayas given by Mr. Middlemiss (Mem. Geol. Surv. India, vol. xxiv, pt. 2) illustrate the process in operation, and in the North-West Highlands of Scotland we have the actual base of such a mountain chain exposed to view.

[3] It should be noticed that a spherical surface also, if it cuts a sphere at all, will necessarily have a circular outcrop. No other form of surface, I believe, has a similar outcrop, excepting only in certain definite positions. A cylindrical surface, for example, will crop out in the form of a circle, if its axis coincides with a diameter of the sphere, but not otherwise. If the thrust-plane be a portion of a spherical surface, it is impossible to determine its dip from an inspection of its outcrop alone.

It is not, however, to be expected that the angle thus deduced from the form of the mountain chain will agree with the dip of the boundary fault along its foot; for in a modern mountain chain the actual base will seldom be exposed, and the faults which are visible at the surface probably bear the same relation to the main thrust-plane that the minor thrusts in the North-West Highlands bear to the major thrust-planes of that region. It is only when the mountain chain has been dissected to its very base that we can hope to see the surface on which the main movement occurred.

If I were to attempt, on this view, an ideal representation of the Himalayas, I should draw, some little distance below Middlemiss's Section VI, a thrust-plane making an angle of 14° with the horizontal. The resemblance of the structure of the chain to that of the North-West Highlands would then be conspicuous. Most of the faults which are visible at the surface would appear as minor thrusts, but it is possible that the great thrust-plane which brings the crystalline schists upon the later beds was at one time the basal plane of the range.

I have no desire to argue that all mountain ranges lie upon the outcrops of thrust-planes, or that there is necessarily a thrust-plane wherever Professor Sollas has drawn one of his small circles. But it remains certain that if a thrust-plane is a true plane, its outcrop on the globe must be an arc of a circle, and that some mountain chains are defined along their convex margins by thrust-planes. Here, then, we seem to have an explanation of some of Professor Sollas's small circles.

POSTSCRIPT.—After the proofs of this short note had left my hands it occurred to me that the Calcutta earthquake of 1897 might throw some light on the existence of the basal thrust-plane which I have imagined in the Himalayas. It appears from Mr. Oldham's valuable memoir on the subject that the earthquake originated in Assam and not in the Himalayas themselves; but it is interesting to find that Mr. Oldham compares the structure of the Assam Hills with that of the North-West Highlands of Scotland, and believes that the earthquake was caused by a movement along a major thrust-plane of low dip, accompanied by displacements along the more steeply inclined reversed faults which reach the surface.

V.—POST-GLACIAL BEDS AT DUNDEE.

By JAMES DURHAM, F.R.S.E., F.G.S.

IN the recently published volume of the Memoirs of the Geological Survey of Scotland, "The Geology of East Fife," by Sir Archibald Geikie, it is argued that since the time when the 100 feet terrace was under the level of the sea there has been no depression of the land in the Firth of Tay, only "a continuous chronicle of gradual, if intermittent, uprise" (p. 321); also that "no trace has survived of any late deposit overlying the peat, so that we cannot be absolutely sure of the position which this sheet of vegetable matter would occupy if all the Post-tertiary deposits of the district could be grouped in chronological order" (p. 318).

In the face of this statement by such a high authority it seems to be very desirable that the details of a section in post-Glacial beds, exposed in digging the foundations of the new Post Office in Dundee, should be recorded in the pages of the GEOLOGICAL MAGAZINE.

As the readers of this Magazine are probably not all familiar with the recent geology of the Firth of Tay, it may be well to state briefly the chronology of these comparatively recent deposits heretofore usually accepted.

At the close of the Glacial Period, or at least when the glaciers had mostly withdrawn from the sea-level, the land stood more than 100 feet lower than at present; the floor of the sea at that time is represented now by a much denuded plateau of sand and gravel, and by a well-worn beach shelf, which indicates a prolonged rest of sea and land at that level; besides the sand and gravel of which the plateau is mainly formed, excavations often bring to light huge boulders which could only have come into their present position by being floated there, which would seem to show that some of the fading glaciers at times reached the sea and detached masses of ice sufficiently large to float these boulders, and, melting, dropped them where they are found.

A slow but apparently uninterrupted upward movement of the land then took place, until it stood about 50 feet lower than at present, when another prolonged rest is indicated by a well-marked beach shelf; between that and the present sea-level the most important beach is that at 25 to 30 feet above the present, but between these beaches there are indications of what seems to have been relatively short rests in the movement. During the long time since the 100 feet terrace, as it is called, was under the sea, denudation has removed a very large proportion of it; especially is this the case in estuaries and river-valleys.

In the Firth of Tay a forest grew on the denuded surface of the 100 feet terrace beds. This forest is represented by a bed of bluish clay in which are entombed roots, trunks, and branches of trees with hazel-nuts; also fragments of insects and sometimes bones of deer are found in this bed; the nuts are much flattened, as if they had been subjected to great pressure under a superincumbent load. This forest bed is found at different levels all over the Firth of Tay, and at some points is seen to pass under low water. This used to be taken to prove that the land stood higher in the time of the forest than it does now, and naturally so, as it is difficult to imagine a luxuriant growth of trees and bushes flourishing fourteen feet below high-water mark in this broad arm of the sea.

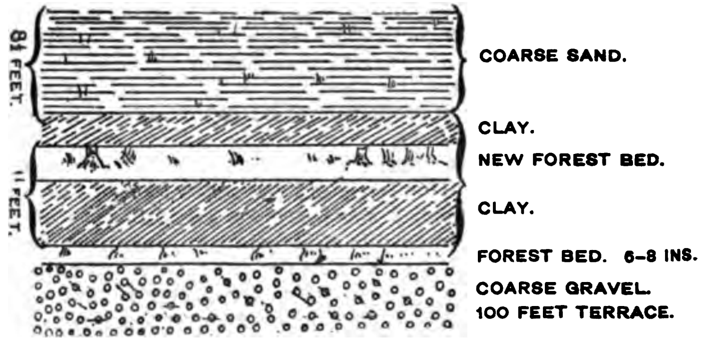
In the upper parts of the Firth of Tay and the Earn another bed or series of beds is found rising some 30 or 40 feet above the present sea-level; these beds consist of clay, sand, and silt, and are known as the Carse Clays.

Now it is clear that if the Carse Clays are laid down on the top of the forest bed, not only had the land stood higher than at present in the first instance, but had been subsequently depressed at least to the level of the top of the Carse Clays, as these are evidently sedimentary deposits in the waters of the Firth.

It is stated on the most reliable authority that in excavations and well-borings in the Carse of Gowrie the forest bed has been repeatedly penetrated. (See Professor James Geikie's "Prehistoric Europe," pp. 391, 392.)

In digging the foundation of the new Post Office at Dundee, a section was exposed which seems to throw a valuable light upon the question as to the succession of these beds, for here we have "deposits of the district grouped in chronological order." The situation of this section is about a quarter of a mile back from the natural foreshore of the Firth (docks and similar works extending far out into the estuary); between the section and the shore a ridge of rock runs for a considerable distance parallel to the margin of the Firth; like the post-Glacial beds to the north of it, it is completely covered by buildings, and like them is only exposed during excavations in connection with alterations and rebuilding in this the centre of the most ancient part of the city.

The level of the street in front of the Post Office is 38 feet above Ordnance-datum. Allowing for the thickness of the blocks and bedding of the street, the top of the section is approximately 35 feet above that base-line, just about the average height of the Carse Clays in the upper part of the Firth. As the total thickness of the beds exposed would be about 25 feet, the bottom of the section would be a little above the present reach of the tide.



Section exposed in digging the foundations of the new Post Office, Dundee.

The excavation revealed the following succession of strata:—At the bottom some five or six feet of coarse gravel, the denuded remains of the 100 feet terrace, then six or eight inches of the far extending forest bed, as usual much compressed; this is succeeded by 11 feet of clay, above which is 8½ feet of coarse sand.

I was indebted to the Inspector of Works for the measurements, so that they may be accepted as absolutely reliable.

An interesting and previously unobserved feature is revealed by this section of the Carse Clays: an upper bed of trees and bushes occurs a little above the middle of the clay, the roots extending for a considerable distance downwards, while the evenly bedded clay of more recent deposit completely buries it several feet deep before the conditions that caused the deposit of the coarse sand supervened.

The occurrence of this upper forest bed would seem to indicate that there had been an interruption of the subsidence, or even re-elevation of the land, during the deposition of these clays, to admit of the growth of the trees and shrubs that form this bed.

That there is good ground for assuming that the gravel exposed at the bottom of the section represents the 100 feet terrace is supported by the records of a deep well-boring made a little to the westward of the Post Office. After passing through similar beds of sand and clay and some 10 or 12 feet of gravel, it, before entering the rock, encounters some 8 or 10 feet of tenaceous blue clay, undoubtedly the Till resting on the surface of the Andesite rock of the district.

With the well-boring and the Post Office excavation, we have a complete series of the Glacial and post-Glacial beds superimposed one on the other: Till, 100 feet terrace, forest bed, and Carse Clays. It seems to me that here we are "absolutely sure of the position which this sheet of vegetable matter *does* occupy."

REVIEWS.

I.—The Zones of the White Chalk of the English Coast. By A. W. Rowe, M.D., F.G.S. Parts I (Kent and Sussex), II (Dorset), and III (Devon); with plates and sections. Published in the Proceedings of the Geologists Association, vol. xvi (1900), vol. xvii (1901), and vol. xviii (1903).

(PLATES XV and XVI.)[1]

WITH the publication of his third paper (on the Chalk of the Devon coast) Dr. Rowe has completed his description of the four chief accessible sections through the Middle and Upper Chalk which are to be found in the cliffs of our southern coast. His papers are doubtless in the hands of most of those who are interested in the Chalk and its fossils, but there may be a few readers of this Magazine both at home and abroad who have not seen them, and in any case it seems fitting that such a series of papers should receive some notice, if only because they deal so fully with the zonal distribution of fossils in the Chalk of Southern England that they merit attention both from the palæontologist and the geologist.

In the introduction to his first paper, Dr. Rowe is careful to define the point of view from which he attacks the subject. He says:

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[1] [Permission to reproduce the two plates which accompany this article (Plates XV and XVI) has been granted by Dr. A. W. Rowe, F.G.S., the author of the paper, Professor H. E. Armstrong, F.R.S., who is the author of the photographs, and by the Council of the Geologists' Association, who published Dr. Rowe's memoir.—Edit. Geol. Mag.]

"the writer pins his faith to Zoology, and to Zoology alone, for while it is true that broad lithological features give us a natural division-line between certain zones in some localities, it is equally clear that these same features fail us in the case of identical zones in other districts; but the fossils never fail us if we collect with sufficient care." This is doubtless true in the case of a coast-section, where a long tract including several zones is exposed and every bed is accessible, but it is not true of inland sections, which are usually isolated quarries or short railway cuttings, often much obscured by talus, and only accessible at certain points. In such places fossils do often fail us, as Dr. Rowe will find if he ever essays to carry his researches inland.

The value of Dr. Rowe's work lies in his demonstration that an ordinary cliff-section of Chalk affords ample material for the establishment of zones and for their exact local delimitation. Incidentally, of course, he has recorded much valuable stratigraphical information, and has largely increased our knowledge of the fossils of the English Chalk. There are, indeed, few workers who are both willing and able to devote themselves to the systematic collecting of fossils from every accessible foot of a long series of beds; few men would voluntarily spend all their vacations in collecting thus exhaustively from one set of beds, while members of the Geological Survey cannot do so, because they are primarily surveyors and have to give most of their time to the work of mapping. If instead of a mere fossil-collector the Survey had a field-palæontologist, a man of scientific training who ranked equally with the surveyors, the descriptive work of the Survey would undoubtedly be improved.

To produce good stratigraphical work there should be organised collaboration between the surveyor and a palæontologist, unless the two capacities are combined in one man. In appreciating Dr. Rowe's work we must remember that he does not put it forward as stratigraphical work; he calls his papers *zoological*, but inasmuch as they deal with zones they are essentially stratigraphical, and only want stiffening with a little more lithological detail to make them complete stratigraphical studies. As it is, his descriptions are frequently incomplete because he omits to notice obvious lithological peculiarities. Thus the zone of *Rhynchonella Cuvieri* near White Nothe is dismissed in eight lines, and the same zone as shown at Mupe Bay in six lines, although its lithology is abnormal and interesting. I point this out simply because the work he has done is so good and so full of detail that one regrets he did not include what would have made it a finished study.

In reviewing the papers which have suggested the above remarks we shall briefly notice the salient points of each. In his first (on the Chalk of the Kentish coast) he commenced with the Margate Chalk, and showed that the zone of *Marsupites* is divisible into two bands or sub-zones, a lower characterised by *Uintacrinus* and an upper to which *Marsupites* is restricted, and he has since found that this subdivision holds good throughout the south of England. The next critical point was the discrimination of the zones of *Micraster* *coranguinum* and *M. cortestudinarium*, and this he was only able to accomplish after a detailed study of the genus *Micraster*, the results of which were published elsewhere. He places the junction, not where *Micraster præcursor* and *M. cortestudinarium* are first found in the descending succession, but where certain special forms of these species come in and are associated with *Holaster placenta*, *H. planus*, and some other fossils.

In the same way a careful collecting of fossils foot by foot enabled him to fix approximate limits to the zones of *M. cortestudinarium* and *Holaster planus*. Here I may remark that Dr. Rowe seems to have been under the impression that the term Chalk Rock had been applied by some previous writer to a certain part of the zone of *Hol. planus* at Dover; possibly he misunderstood some expressions in Mr. W. Hill's paper on the Middle Chalk of that place; in any case Mr. Hill and I agree with him that no true Chalk Rock exists there.

Dr. Rowe's work in Sussex was fruitful in new results. The zones of *Holaster planus*, *Micraster cortestudinarium*, and *M. coranguinum* were defined and distinguished by means of the essential features of the tests of the Micrasters; but though it is very interesting to know that this can be done by reliance on the forms of *Micraster* alone, it is obvious that some other means of delimitation must be adopted inland when a sufficient number of Micrasters cannot be obtained, and I doubt whether the zones will remain permanently as defined by Dr. Rowe. This, however, is a question for the future.

With the zone of *Marsupites* we are on safer ground; neither *Uintacrinus* nor *Marsupites* had previously been found on this coast, in spite of special search for them. Professor Barrois had assigned far too great a thickness to this zone in Sussex, and he had never properly defined it. The actual limits within which Dr. Rowe found the plates of these Crinoids was a thickness of 77½ feet, but above this there is a thickness of 20 feet which he regards as more properly included in this than in the overlying zone, and I have his authority for stating that this 20 feet was omitted by mistake in the tabular measurements on pp. 333 and 336. The total thickness of the zone is therefore 97½ feet, and the exposed portion of the *Actinocamax quadratus* zone at Seaford Head only 150 feet.

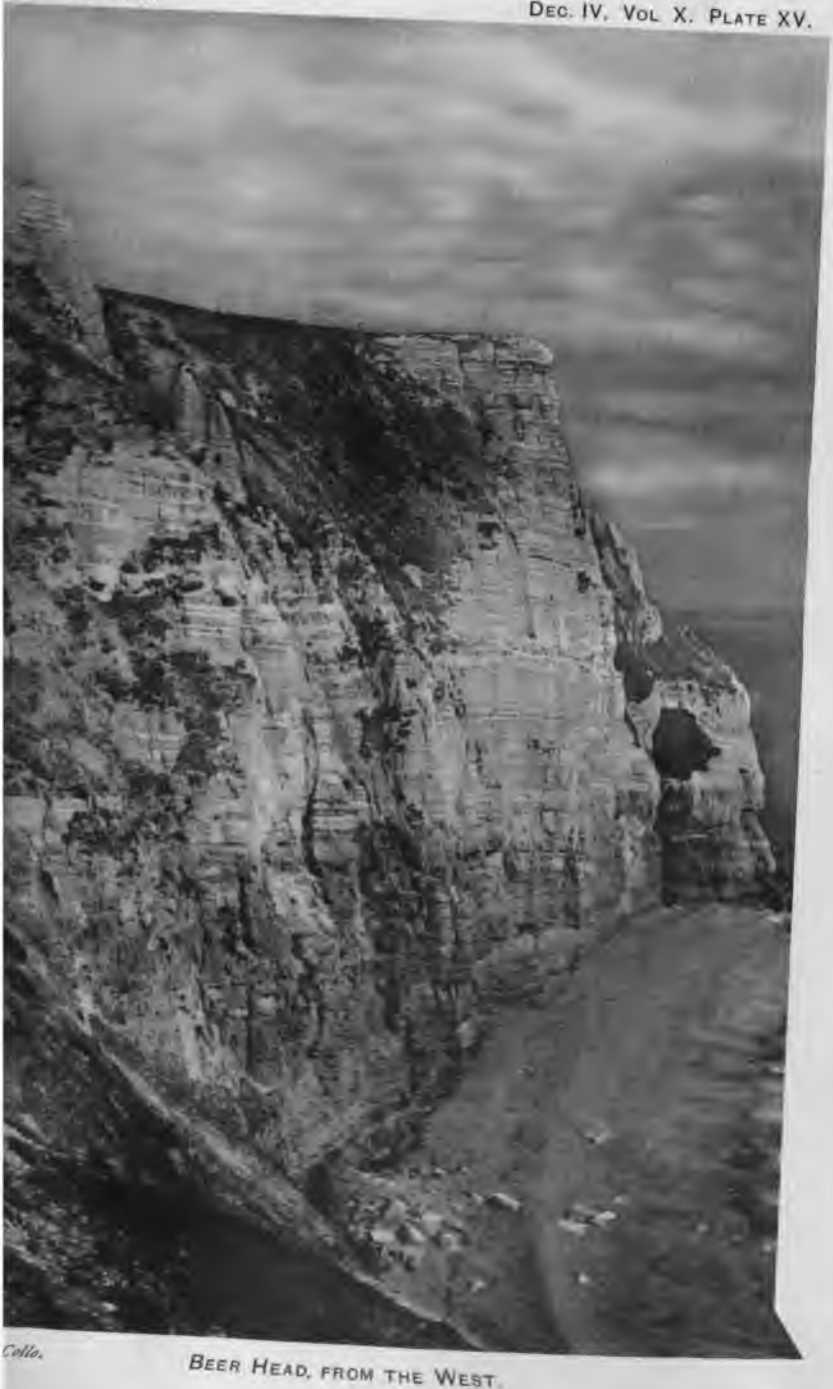
Finally, in this paper he established the zone of *Actinocamax quadratus* on a firm basis as one of the chief zones in the English Chalk, showing that it contains a fauna which is distinct from that of the zone of *Marsupites* below, and from that of *Belemnitella mucronata* as developed further west. At the same time he pointed out that the prevalent Belemnite is not *A. quadratus*, but *A. Merceyi*, which he has since identified with the *A. granulatus* of Blainville.

Dr. Rowe's second instalment was on the Chalk of the Dorset coast, and this paper is illustrated by eight excellent photographs of the cliffs, and two maps on the scale of 6 inches to a mile, drawn by Mr. C. D. Sherborn. The plates show what can be done by means of photographs and key-slips to illustrate the stratigraphical detail of a cliff-face, and a comparison of the text with that of the Survey memoir on the same area shows how much more information can be elicited by a careful collection of fossils from the Chalk.

... with an excellent description of the cliffs ... Bats Head, which comprises all the ... Chalk from the zone of *Rhynchonella* ... *gracilis*. He points out that the ... nodules which had been called ... the upper part of the *Terebratulina* ... Rock. To my own know... Isle of Wight: in both areas th... found in the lower part of ... which consists of nodular chalk ... Each zone in the White ... of its characteristic fossils ... thickness than 320 feet ... higher zone of *Belemnitella* ... land.

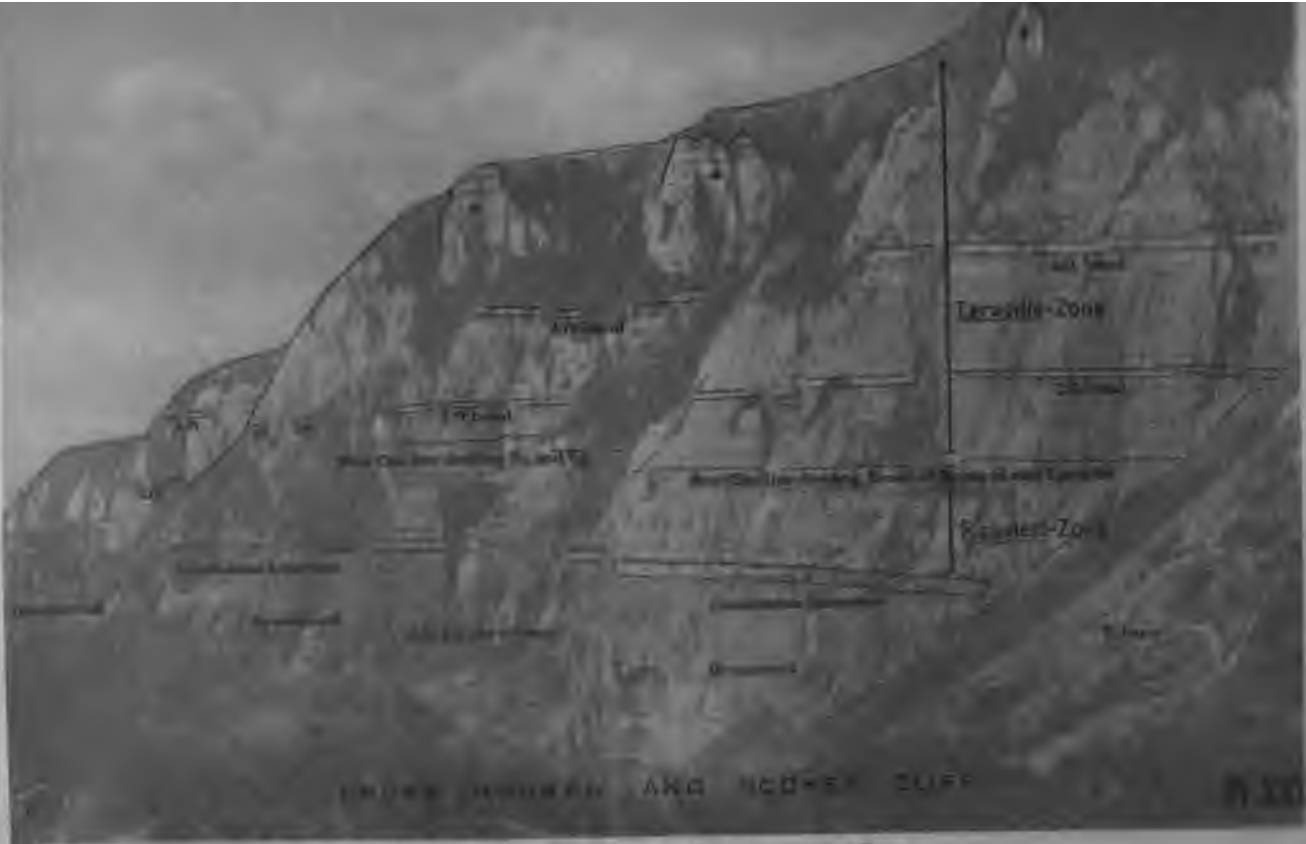
... cliffs are treated ... War Cove, Lulworth, ... Bay: and though in some ... are of small value, ... is to the composition of ... that of any previous ... from Ballard Point to ... difficulties of access will ... *Act. quadratus*, and ... correctly indicated ... of the Chalk of the ... year, and is in some ... most fully and ... includes twelve plates ... and Branscombe. ... means of ... has been known ... in 1876. ... part of the Lower ... the Beer Stone ... and accurate ... my possession ... Survey memoir ... Dr. Rowe has ... places more ... excellent guide

... Regis, he shows ... *Rhynch. Cuvieri*, ... and his careful ... zones in this ... The same ... and I agree with ... *arium* is not



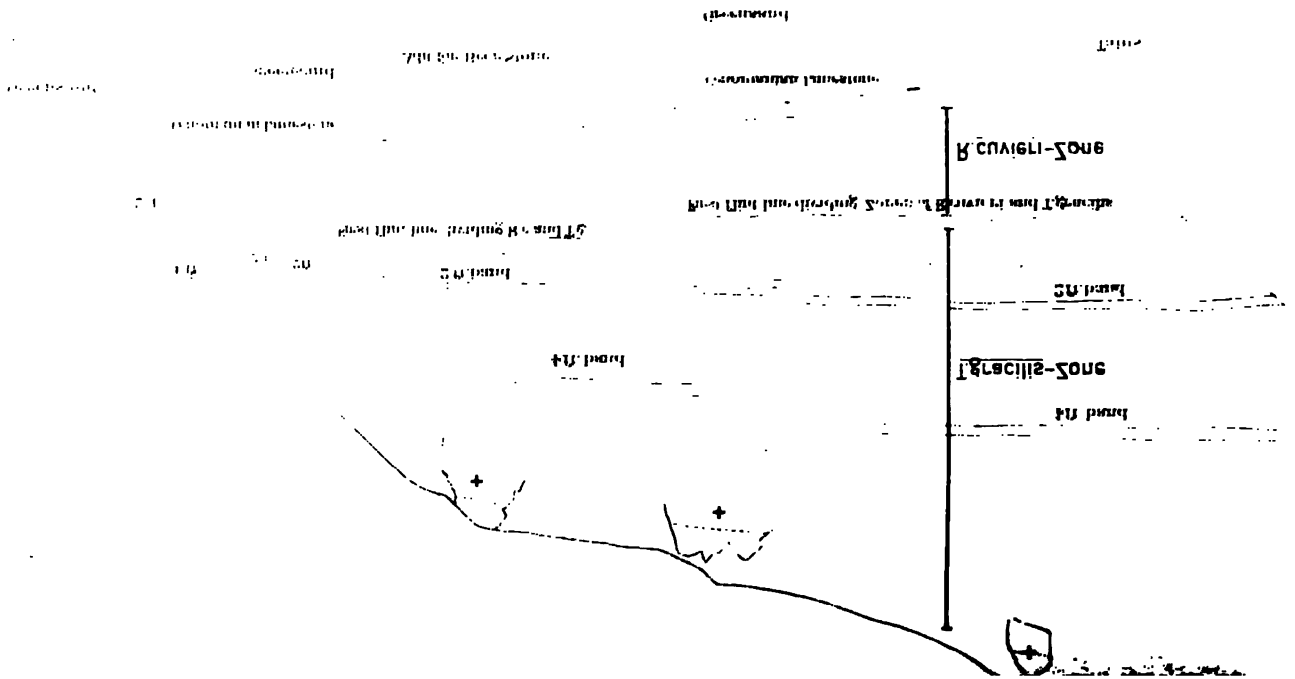
Collo.

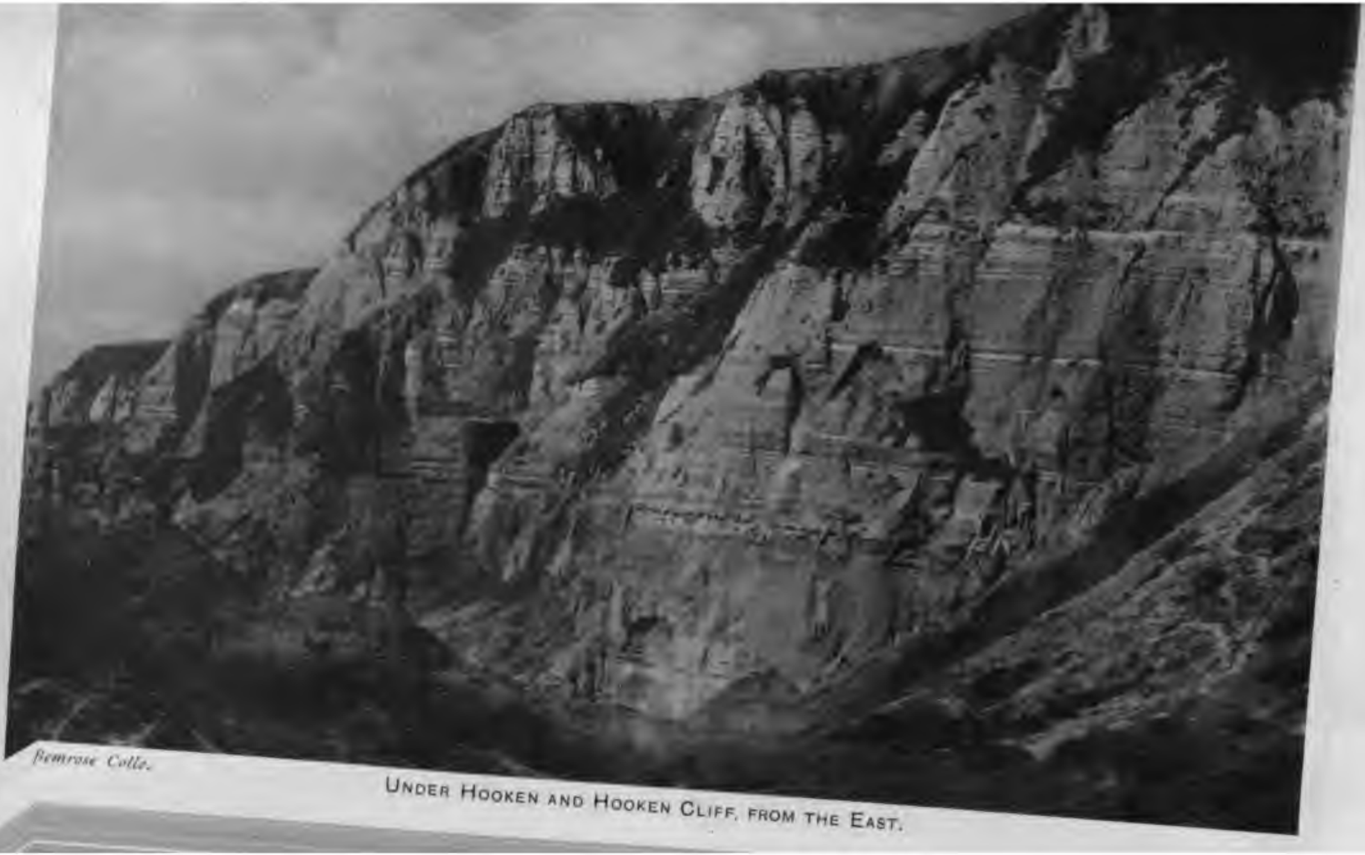
Beer Head, from the West.



Upper [illegible] and [illegible] Cliff from the East.

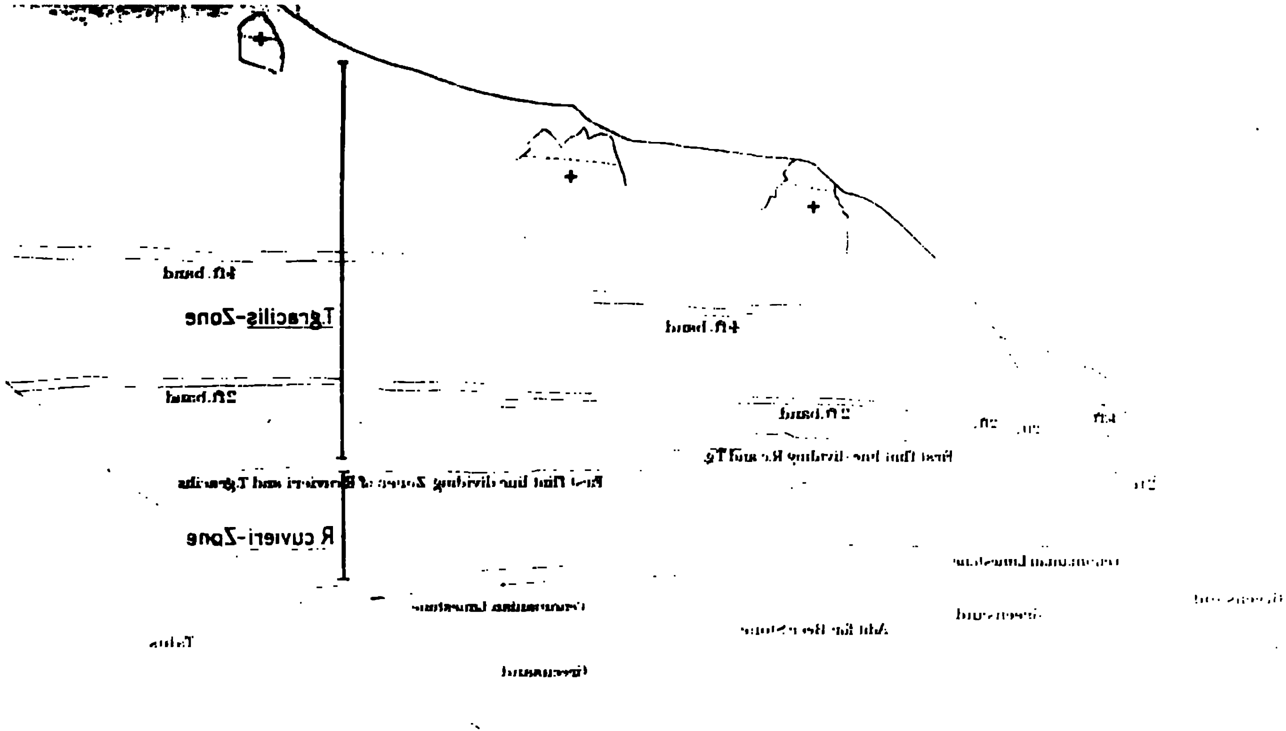
UNDER-HOOKEN AND HOOKEN CLIFF





Bemrose Collo.

UNDER HOOKEN AND HOOKEN CLIFF, FROM THE EAST.



UNDER-HOOKEN AND HOOKEN CLIFF

PL. XVI.

reached at any place along this coast, and that evidence of the higher zones is only to be found in the flints of the overlying gravels.

The interesting section of Beer Head and Hooken Cliff is fully described, and is illustrated by four plates which are excellent both from an artistic and geologic point of view. Of these plates our readers will be able to judge from the two examples which are here introduced. The first (Plate XV) is a view of Beer Head itself, a sheer cliff of nearly 300 feet in height, of which Dr. Rowe says, "no section on this coast gives one so diagrammatic of the zonal boundaries as Beer Head, for none is so complete." The second (Plate XVI) shows the Hooken Cliff, behind the great Southerndown landslip; this rises to a height of 400 feet, and presents a face of beautifully weathered beds. Here, by means of a convenient talus-slope, a continuous section can be examined through a large part of the Middle Chalk, the Cenomanian (24 feet thick at this point), and the upper half of the Selbornian (Upper Greensand). At this locality one of the most interesting phenomena is the local break and gradual disappearance of certain beds in the western part of Hooken Cliffs. Dr. Rowe is quite correct in stating that about 70 feet of Chalk is missing above Mitchell's Rock, but he is mistaken in thinking that the whole of the Cenomanian is also absent; I found the basal part of the Cenomanian limestone both in Martin's and in Mitchell's Rock, and particulars of the beds which compose these fallen masses are given in a memoir which is on the eve of publication. I also differ from Dr. Rowe in his reading of the zones in the Berry Cliffs. But these are minor points and do not detract from the great value of his paper. Like each of the other papers, it concludes with a 'zoological' summary and with a tabulated list of fossils showing the zonal distribution of each species.

The careful and thorough manner in which Dr. Rowe has worked the South Coast sections merits our hearty recognition, while the illustrations are deserving of the highest praise. It is satisfactory to know that the Chalk cliffs of Yorkshire will soon be similarly described and illustrated.

For the benefit of those who are not members of the Geologists' Association, it may be mentioned that each of Dr. Rowe's papers can be purchased separately from Mr. E. Stanford, the price of Part I being 1*s.* 6*d.*, that of Parts II and III being 3*s.* each.

A. J. Jukes-Browne.

MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES.

II.—The Geology of the Country near Leicester (Explanation of Sheet 156). By C. Fox-Strangways, F.G.S. 8vo; pp. vi and 122, with 15 text illustrations. Printed for H.M. Stationery Office. London: E. Stanford, Long Acre (or of Messrs. Dulau & Co., 37, Soho Square, W.), 1903. Price 3*s.*; price of Sheet-Map 156, colour-printed, 1*s.* 6*d.*

THANKS to the energy of the Director, Mr. J. J. H. Teall, there has been a steady output of memoirs by the staff of the Geological Survey, as may be seen by reference to this and to the June Number of the GEOLOGICAL MAGAZINE (pp. 269–277).

In the present memoir, by Mr. C. Fox-Strangways, we have a description of the geology embraced in the area contained in Sheet 156 of the new series one-inch Map of England, which covers parts of central and eastern Leicestershire and a part of Rutland. Considerable changes have been made in the delineation of the geology of this part of the Midlands, due principally to the use of larger scale maps, which has enabled the outcrop of the granite and other older rocks in the neighbourhood of Mountsorrel to be shown with more exactness than was possible on the old maps of smaller scale. The outcrop of the Rhætic beds has also been traced, and slight modifications have been made in the mapping of the Keuper Marl; the subdivisions of the Middle Lias, too, are now shown with greater precision.

The Drifts, which cover so large an extent of the area embraced in this map and memoir, have been surveyed in detail for the first time; they form the most striking feature of the map, and well exemplify their plateau-like character.

The alluvium, both in the main and smaller valleys, has been carefully and accurately traced, and tends to bring out more clearly the drainage system of the country. The river terraces are also shown.

A new feature, which will be observed on the colour-printed map, is the introduction on the margin of a longitudinal section from south-east to north-west, showing the general structure of the ground, taking in the Charnwood rocks and Mountsorrel Granite in the north-west, with the Keuper Marls about Syston, followed by the Rhætic beds and Lower Lias Limestone and shales, with the Middle Lias sandy shales and rock-bed resting on it, and also occasional outliers of Inferior Oolite forming the high ground of Robin-a-Tiptoe, Whatborough Hill, and other eminences (see also page-section given at p. 5 of memoir). Everywhere between the main valleys and their tributaries the Great Chalky Boulder-clay, with intercalated beds of sand and gravel, together with the Upper and Lower Older Boulder-clay, cover the country in wide sheets. The district is thus essentially a clay country, the Keuper Marls, Lias Clays, and Boulder-clay all contributing to its argillaceous character, and influencing its soils from an agricultural point of view.

The older formations that come to the surface within the limits of the map occupy a very small space, but they have been proved to extend further beneath the newer rocks at Leicester and elsewhere. They include a small outcrop of the pre-Cambrian slates of Bradgate Park and the intrusive granite and other rocks of Mountsorrel, which form the fringe of the Charnwood Forest district. The principal formations, however, are the Trias and the Lias, which practically cover the whole of the district.

The following table gives a list in descending order of the subdivisions of the strata:—

Recent and Pleistocene.	Recent and Post-Glacial.		Alluvium. River-gravels.
	Glacial.		Valley-drift. Chalky Boulder-clay, with intercalated beds of sand and gravel Older Boulder-clay (upper part). Quartzose sand. Older Boulder-clay (lower part). Older sand and gravel (?).
Jurassic.	Inferior Oolite.		Northampton Sands.
	Lias.	Upper Lias.	Shales.
		Middle Lias.	Marlstone rock-bed (zone of *Ammonites spinatus*). Sandy shales and clays with ironstone, etc. (zone of *Am. margaritatus*).
		Lower Lias.	Lower Lias shales, with limestones in the lower part.
Triassic.	Rhætic.		Rhætic beds.
	Keuper.		Keuper Marl with lenticular sandstone beds, and bands of gypsum.
Pre-Cambrian or Archæan.	Charnian.		Granite of Mountsorrel, and associated rocks. Slates, hornstones, and agglomerates of Charnwood Forest.

The Keuper Marl crops out along the Soar Valley, covering a considerable area, but the most extensive formation is the Lower Lias, which crosses the centre of the district; between these is a narrow band of Rhætic shales, which has now been mapped for the first time. This is followed by the Middle and Upper Lias, which cover the eastern part of the district, and form the higher ground found in that direction. A few isolated hills of Inferior Oolite rise here and there above the general mass of the Upper Lias Clay. Finally, the whole of these strata are more or less covered by Boulder-clay and sands, which have somewhat altered the general character of the country.

The soil of the country, being in the main derived from the underlying formations, is mostly clay of a very retentive character. It is diversified here and there by beds of sand and gravel, which render it much lighter. This is particularly the case with the alluvial gravel that occurs along the margin of the Soar Valley, especially about Syston. In the eastern part of the area the rock-bed of the Middle Lias, where not covered by Drift, also forms a light rubbly soil, which is the best arable land in the district. In consequence of the large proportion of heavy clay land the greater part of the country is devoted to grazing purposes, and is noted for its extensive pastures and its excellence as one of the finest hunting countries in the kingdom.

Although there is no coal-mining in the area now under consideration, the proximity of the coalfields to Leicester, and their early connection by one of the first railways made in the kingdom, have enabled that town to become an important manufacturing centre.

A large industry, and one which has greatly increased of late years, is the quarrying of roadstone. This is actively carried on at Mountsorrel, where the granite forms an excellent material both for mending roads and for pavements; it is also used in the preparation of artificial flagstones. These quarries are very extensive, and being connected by branch lines with both the Midland and Great Central Railways, a large amount of road-metal is sent away to other districts.

The Keuper Marl is extensively used along the Soar Valley for the manufacture of bricks, and has entirely superseded those made from the Glacial and Liassic Clays, which were worked to a small extent locally for this purpose.

The rock-bed of the Middle Lias contains a certain amount of ironstone and was formerly worked at Tilton, but it does not appear to have been profitable.

Gypsum occurs in the Keuper Marl at Thurmaston, and other bands have been met with in borings; but it has not been used commercially in this district, although extensive works exist to the north between Kegworth and Gotham.

The limestone bands in the lower part of the Lias, from which the well-known cement at Barrow is made, are worked for lime at Kilby Bridge, but the beds are more shaly and impure than at Barrow.

Building-stone is also a scarce article, the Lias rock-bed being generally too soft and friable for the purpose. The Middle Lias yields some hard fossiliferous blocks (called 'jacks'), which have been used on the Melton and Market Harborough Railway in the construction of bridges, which appear to stand fairly well.

A carefully prepared catalogue of fossils obtained from the Trias, Rhætic, and Lias formations of Leicestershire and Rutland (pp. 95–115), giving the range and localities for each, will be found of great use to the palæontologist.

A long list of borings and well-sections is recorded. There are two well-printed half-tone plates: (1) "Hawcliff Hill, Mountsorrel, Crags of Granite, showing horizontal bedding"; (2) "Railway Cutting at Tilton, showing Upper Lias Shales resting on the Rock-bed of the Middle Lias." The other thirteen illustrations are in the text (a few of them being from Professor J. W. Judd's memoir "Geology of Rutland," prepared in the age of woodcuts).

The new map (No. 156) of which this memoir is a description is one of the best and most successful examples of colour-printing yet issued by the Geological Survey; the arrangement of the colours (which of course corresponds with the general arrangement of the drainage-lines of the country) giving this sheet a most pleasing and artistic appearance, the colours producing a very harmonious effect.

III.—The Geology of the Country around Reading; being the Explanation of Sheet No. 268. By the late JOHN HOPWOOD BLAKE, Assoc. M. Inst. C. E., F. G. S., with contributions by

Wm. Whitaker, B.A., F.R.S. Edited by H. W. Monckton, F.L.S., F.G.S. 8vo; pp. 92, with 13 illustrations in the text. Printed for His Majesty's Stationery Office by Wyman & Sons. London: E. Stanford, Long Acre (or Dulau & Co., 37, Soho Square, W.), 1903. Price 1s. 6*d*.

THE author of this memoir, Mr. John Hopwood Blake, joined the Geological Survey in 1868, and worked in Somerset, Suffolk, and Norfolk until 1884, when he removed to Reading and was for many years occupied on the re-survey of that neighbourhood, giving special attention to the Drifts, which before had only been partially mapped. He then proceeded to Oxford, where he laboured on, having nearly completed the MS. of this memoir at the time of his death, March 5th, 1901.

The geology of the Reading area has been rendered classical as the scene of some of the early labours of Prestwich, the fine sections of the mottled plastic clays, so long worked as tile-earth, having led him to adopt the name 'Reading Beds' for the varied group of strata which here intervene between the Chalk and London Clay. The district is one in which the action of rivers and changes in their courses are conspicuously shown, a subject which has been dealt with by Mr. H. J. Osborne White and others, but requires to be discussed in relation to a much wider area than is covered by this Sheet (No. 268).

Mr. H. W. Monckton, who has devoted much labour for many years to the elucidation of the Bagshot Beds and the Gravels of the Thames Valley, has kindly undertaken the task of editing Mr. J. H. Blake's MS. for publication, and, whilst retaining all Mr. Blake's notes, he has freely inserted additions from his own notebook, especially in the chapters relating to the superficial deposits, for which Mr. Monckton may thus be considered to some extent responsible. The map, it is to be regretted, has not at present been printed in colours, but two editions, with and without Drift, were issued in 1898 *hand*-coloured. We hope the superior colour-printed map will shortly be obtainable for this district.

The country around Reading embraced in Sheet 268 represents an area of 216 square miles; that portion on the north of the Thames being in Oxfordshire, and the remainder in Berkshire, with the exception of a somewhat irregular narrow strip along the south, which is in Hampshire. Reading, the capital of Berkshire, is situated near the central part of the area. The area is drained by the River Thames and its tributaries, the Pang, the Kennet, and the Loddon, together with minor streams.

The following is a list of the geological formations which are shown on the map by distinctive colours:—

Recent	Alluvium. Tufa.
Pleistocene	Loam. Valley-gravel. Clay-with-flints and loam (overlying the Chalk). Plateau-gravel. Pebble-gravel.

Eocene	Upper Bagshot Beds. Bracklesham Beds. Lower Bagshot Beds. London Clay. Reading Beds.
Cretaceous	Upper Chalk. Middle Chalk.

Only the Middle and Upper Chalk come to the surface in this district, but at Winkfield, in Windsor Forest, a boring passed through the whole formation, and the thickness was found to be 725 feet, of which 219 feet was Lower Chalk, 169 feet Middle Chalk, and 337 feet Upper Chalk.

The Chalk exists throughout the district, but is only found at the surface over a comparatively small part, for, in the southern half of the area and in parts of the northern half, it is covered by Eocene strata often of great thickness, and in other parts the Chalk is hidden under beds of Drift.

The Middle Chalk is divided into two zones, namely:—

2. The zone of *Terebratulina* (*gracilis* ? var. *lata*, Eth.).
1. The zone of *Rhynchonella Cuvieri*, D'Orb.

The zone of *Terebratulina* consists of smooth white Chalk, and in it nodules of flint are *occasionally* found. It has been termed the zone of *Terebratulina gracilis*, but it is now known, through the researches of Dr. F. L. Kitchin, that this species does not occur below the uppermost division of the English Chalk. The name to be used for the species of *Terebratulina* in the Middle Chalk has yet to be decided; it has been called *T. gracilis*, var. *lata*, by Mr. Etheridge.

The *Middle Chalk* runs down the Thames Valley from Goring and Streatley by Basildon to Pangbourne. Details of the several exposures of this division are given on p. 8 by Mr. Jukes-Browne.

The *Upper Chalk* consists of soft white Chalk, more or less evenly bedded, with numerous irregular nodules of flint along the planes of bedding, and sometimes in the Chalk itself between the planes. Thin seams of tabular flint occasionally occur along the bedding-planes, or fill fissures or joints inclined at various angles to them. At its base is the *Chalk Rock*, a cream-coloured limestone with glauconitic grains and many green-coated nodules.

The Upper Chalk is divided into several zones, only the three lower of which have been identified in the Reading district, namely:

3. The zone of *Micraster coranguinum*, Leske.
2. The zone of *Micraster cortestudinarium*, Goldf.
1. The zone of *Holaster planus*, Mant.

(1) The zone of *Holaster planus* includes the Chalk Rock, which, as has been said, forms the base of the Upper Chalk. The average thickness of this zone in the Thames Valley is about 20 feet. Several localities and sections are recorded, e.g., an old quarry facing the Thames in Harts Lock Wood opposite Basildon, and in the road-cutting on White Hill, east of Goring.

(2) The zone of *Micraster cortestudinarium*, Goldf. The average thickness of this zone in the Thames Valley is about 60 feet, and

there seems to be some thickness of Chalk exposed in several pits which is referable to it. Part of the zone is well exposed in the railway cutting west of Pangbourne, where the beds are bent up into a slight anticlinal curve, of which a sketch is given.

(3) The zone of *Micraster coranguinum*, Leske. Along the valley of the Thames the thickness of this zone is about 200 feet. Exposures in quarries are numerous from Whitchurch to Shiplake, and probably all belong to the same zone.

At Mapledurham and Chazey Farm, at Caversham, and south-east of Wargrave in Berkshire, similar exposures of this zone can be seen. Chalk is exposed in most of the valleys in the north-western part of the area, and the fields are in many places thickly covered with flints.

Reading Beds.—There is a great break in time between the Chalk and the Reading Beds, which are here found resting upon it; for not only are the highest beds of the Chalk wanting in this area, but a considerable series of Eocene strata which in other places is found below the Reading Beds is also absent. The Reading Beds accordingly here lie upon a greatly but evenly eroded surface of the Chalk.

The whole formation in this area varies from about 70 feet or less to 90 feet in thickness, and is composed of variously coloured mottled plastic clays and more or less loose sands; the clays are the upper part, and vary from 30 to 50 feet in thickness, the sands forming the lower part, being from 20 to 40 feet thick. The 'bottom bed' consists of stiff dark bluish-grey clay from 7 to 10 feet in thickness.

The main mass of the Reading Beds extends beneath the surface in the southern half of the district, and at its outcrop forms a narrow band running nearly due east and west. There are also several outliers resting on the Chalk to the north, some to the north and others to the south of the Thames. These are described in detail.

Mr. W. Whitaker contributes many notes full of valuable information on sections, well-sinkings, and borings. A section given, fig. 9 (p. 29), is taken from Sir J. Prestwich's paper (Quart. Journ. Geol. Soc., 1854, vol. x, p. 88) on the Basingstoke and Newbury Branch Railway; and one by Whitaker, fig. 10, at Rose Kiln, south of Reading, giving excellent exposures of the Reading Beds.

The famous bed of fossil Oysters (*Ostrea bellovacina*, Lmk.) had, it appears, attracted attention before 1699, and in a letter from Dr. Brewer to Dr. Sloane (see Phil. Trans., 1700–1, vol. xxii, p. 485) the writer mentions that this remarkable deposit had been "exposed over an area of between five and six acres of land, resting on a hard rocky Chalk, the stratum of greensand with oyster-shells being nigh two feet deep."

Dr. Buckland (in 1817), Robert Plot, author of the "Natural History of Oxfordshire" (1705, p. 120), Dr. Wm. Stukeley, "Itinerarum Curiosum" (1724, p. 59), and other writers are referred to who had observed this interesting geological deposit. Mr. E. T. Newton, F.R.S., contributes some notes on plants from the Reading Leaf-bed, first described by Sir J. D. Hooker (Quart. Journ. Geol. Soc., 1854, vol. x, p. 163).

The London Clay (pp. 42–52) is next dealt with, and a list of the fossils of the Basement Bed is added. Then follows a description of the Upper Bagshot, Bracklesham, and Lower Bagshot Beds (pp. 53–59). The Clay-with-flints and Pebble-gravel are described in a separate chapter (pp. 61–62), followed by the Plateau-gravel, which forms extensive layers often 20 feet in thickness, from 160 to 500 feet above the sea-level.

The memoir ends with an account of the Valley-gravel, Loam, and Recent deposits. An appendix of principal works and authors' names who have contributed to the geology of the district, and a good index, complete this useful memoir. There are thirteen illustrations in the text, ten of which represent fossils. This memoir is published at 1*s*. 6*d*. in paper wrapper.

MEMOIRS OF THE GEOLOGICAL SURVEY OF SCOTLAND.

IV.—The Geology of North Arran, South Bute, and the Cumbraes, with parts of Ayrshire and Kintyre (Sheet 21 of the one-inch Geological Map of Scotland). 8vo; pp. viii and 200, with 10 plates and 2 figures in the text. Printed fot H.M. Stationery Office by James Hedderwick & Sons, Glasgow. J. Menzies & Co., Edinburgh (or of Messrs. Dulau & Co., 37, Soho Square, London, W.), 1903. Price 4*s*.

The Description of North Arran, South Bute, and the Cumbraes, by W. Gunn, F.G.S.; Part of Ayrshire, by Sir A. Geikie, D.C.L., F.R.S.; Part of Kintyre, by B. N. Peach, F.R.S.; On the Petrography of the Tertiary Igneous Rocks of Arran, South Bute, and the Cumbrae Islands, by A. Harker, M.A., F.R.S.

THE present memoir describes the geology of the area embraced in Sheet 21 of the one-inch Geological Map of Scotland, and includes the north part of Arran, South Bute, and the Cumbraes, with parts of Ayrshire and Kintyre. The ground in Ayrshire was surveyed by Sir A. Geikie, who also mapped a narrow belt along the east coast of Arran in 1872. Bute and the Cumbraes were surveyed by Mr. Gunn, and the small area in Kintyre by Mr. Symes. The survey of the southern part of Arran was commenced in 1892 by Mr. Gunn, who gradually traced his lines northwards till he completed the mapping of the whole island; the field-work being carried on under the supervision of Mr. B. N. Peach, F.R.S. The geological description of North Arran, South Bute, and the Cumbraes has been written by Mr. Gunn, that of the Ayrshire Coast by Sir A. Geikie, and that of Kintyre by Mr. Peach. The petrography in chapter xi has been supplied by Mr. A. Harker, F.R.S. In part ii of the Appendix the notes on the petrography of the Old Red Sandstone igneous rocks have been contributed by Mr. Kynaston, and those on the Carboniferous igneous rocks by

Mr. Seymour. While the field-work was in progress petrographical notes on various rocks from this area were also supplied by Mr. Teall, F.R.S., Dr. Hatch, Professor Watts, Professor Grenville Cole, and Dr. Flett.

Considerably more than one-half (about five-eighths) of the area of this Sheet is occupied by sea, the Firth of Clyde and its branches, and the land amounts to only about 161 square miles. The land area belongs to three different counties, and consists of no less than nine separate portions, seven of them being islands or parts of islands, and the other two belonging to the mainland.

In the north-west corner of the map is a small portion (about 13 square miles) of the peninsula of Kintyre in the neighbourhood of Skipness, Argyllshire. On the eastern border is a somewhat larger area (about 16 square miles), part of the county of Ayr. It embraces a strip of coast-land stretching from Largs to near Ardrossan, together with the Horse Island opposite to its southern end. The remaining portions belong to the county of Bute. Near the northern edge of the map occur four of these—the southern parts of the islands of Bute and Inchmarnock, the whole of the Little Cumbrae, and nearly all of the Great Cumbrae. The largest land mass is the northern portion of Arran, nearly three-quarters of the whole area; and the northern end of Holy Island, which closes in Lamlash Bay, completes the list. The extent of coastline in the Sheet is about 91 miles.

Physical Features.—Naturally, from the small size of the separate portions of land, there can be no large streams, but some of the ground rises to a great height, especially in the Isle of Arran. The Kintyre portion is an undulating tableland rising rapidly from the sea-level to a height of 500 or 600 feet, and the highest point is Cruach-an t-Samhlaidh, which reaches to 849 feet above the sea. This area is drained by the Claonaig Water and the Skipness Water. Inchmarnock is a low rocky island of less than 200 feet in elevation. The western side of Bute rises to 279 feet above the sea. Birgidale Butts is 400 feet above the sea. In South Bute the highest points are Suidhe Chatain (517 feet) and Tor Mor (585 feet) near Glencallum. The Great Cumbrae resembles Bute to the north of Kilchattan, and rises to a height of 417 feet above the sea. Some intrusive igneous masses, however, diversify its surface considerably. The Little Cumbrae, rising to 409 feet, is rocky like South Bute, and has a series of gently sloping terraces. On the Ayrshire side is the rocky promontory of Portincross, 456 feet above the sea; much of the border of the Sheet is over 800 feet and at one place exceeds 1,000 feet in height.

The fine peaks of the northern granite mountains, with their deep-cut glens, are the dominant feature of the scenery of Arran. These are contained within a circular area, about 8 miles by 7 across. All the principal streams take their rise in this mass or from a smaller area on the southern edge of the sheet. Some of the chief hills are Ard Bheinn (1,676 feet), A'Chruach (1,679 feet), and Beinn Breach (1,649 feet). Nearly all the highest hills are round or flat-topped. Beinn Bharrain (2,345 feet) and Beinn Bhreac (2,333 feet) are the highest points of a continuous ridge; Meall-nan-Damh (1,870 feet) and Meall Mor (1,602 feet) are isolated conical hills. The streams from these drain west of Loch-na-Davie and north down Glen Catacol.

From the masses of Caisteal Abhail (2,817 feet) and Cir Mhor (2,618 feet) diverge ridges that embrace the glens of Sannox and North Sannox, which drain eastwards, and that of Rosie, which drains southwards, into Brodick Bay. More than twelve peaks in these high ridges exceed 2,000 feet. Goatfell, the highest summit in the island, which attains to 2,866 feet, is on a continuous range of high ground over 2,000 feet in elevation, which runs in a curved line from Cioch-na h-Oighe (2,168 feet), round the head of White Water, past Goatfell, some half-mile down its southern spur. The fine panoramic photographic view from the top of Goatfell, looking north, forms the frontispiece (plate i) of this memoir. It shows admirably the continuous high ridge running in a curved line, on which the so-called north top of Goatfell stands up and forms a prominent peak. For three-quarters of this distance the ridge is nearly everywhere over 2,500 feet, and only falls slightly below that height at one or two points. A ridge which bounds the White Water on the north runs eastward to Am Binnein (2,172 feet). Holy Island is steep and rugged, and rises to above 1,000 feet in height.

Only an outline is attempted of the very complicated geology of the northern part of the Isle of Arran, which forms the bulk of the land in this Sheet, fuller details being reserved for a complete memoir on the island. The principal additions to our knowledge of the geology of Arran made during the progress of the Survey are:—The discovery of the former extension of Cretaceous, Liassic, and Rhætic formations in the island from the presence of fragments of these rocks enclosed in a Tertiary volcanic vent. The definite determination of the Triassic age of the sandstones, conglomerates, and marls of the southern part of Arran, and their unconformability to the Carboniferous rocks. The restriction of the Carboniferous formation to an extremely narrow compass in the island, a much broken and faulted strip which does not extend to the west coast, and the discovery in it of strata of Coal-measure age. The discovery of beds of probably Arenig age in North Glen Sannox in the form of black schists, cherts, and grits, associated with old lavas and volcanic tuffs similar to those occurring near Ballantrae in Ayrshire. The discovery of no less than six different sets of volcanic rocks in addition to that formerly known as occurring in the lower part of the Carboniferous formation. Of these newly discovered volcanic series one is probably of Arenig age, two belong to the Old Red Sandstone period, two are of Carboniferous age, and the newest, which is a huge volcanic vent, is probably of Tertiary age. The age and character of the numerous intrusive rocks, both acid and basic, have also been definitely fixed, and their distribution more accurately determined. While the majority of the intrusive rocks are of Tertiary age, a considerable number belong to the Carboniferous period and some to that of the Old Red Sandstone, while a few are as old as the Lower Silurian period, or even earlier in date than this.

In chapter ii is given a table of formations occurring in Sheet 21, and a general geological description of the area. The following is a Table of the Aqueous Series observed :—

RECENT and POST-TERTIARY.	Subaerial and Fresh-water.	Blown sand.
		Alluvium of stream terraces and old lakes.
		Peat.
	Estuarine and Marine.	Mud and sand of present beach.
		Raised beaches (25 feet).
		Raised beaches (intermediate).
		Raised beaches (100 feet).
DRIFT SERIES.		Sands, gravels, and stratified clays.
		Eskers and glacial shell-beds.
		Erratic blocks.
		Boulder-clay or Till; drumlins.
		Ice-markings on rocks.
CRETACEOUS.		Limestone with siliceous concretions, occurring in volcanic vent.
LIASSIC.		Dark shale with many fossils, occurring in volcanic vent.
RHÆTIC.		Black shale with ironstone and limestone, occurring in volcanic vent.
		Pale-coloured mudstones, occurring in volcanic vent.
TRIASSIC.		Red marls and shales, with white and yellowish sandstones.
		Thick red, yellow, and whitish sandstones, with masses of conglomerate.
		False-bedded red sandstones.
CARBONIFEROUS.		COAL-MEASURES, with contemporaneous lava.
	CARBONIFEROUS LIMESTONE SERIES.	Upper Limestone group.
		Edge-coal group.
		Lower Limestone group.
		CALCIFEROUS SANDSTONES, with intercalated volcanic series.
OLD RED SANDSTONE.		Upper Red Sandstones and conglomerates, with volcanic series.
		Lower Red Sandstones, mudstones, and conglomerates, with volcanic series.
LOWER SILURIAN.		Cherts, grits, and dark schists, associated with a volcanic series (Arenig ?).
METAMORPHIC.		Mica-schist.
		Limestone.
		Slate.
		Gritty schists, or schistose grits.

The Igneous Series are divided into :—

A. Those which are interstratified or contemporaneous with the formations among which they lie : occurring in the Carboniferous, in the Old Red Sandstone, and in the Lower Silurian.

A¹. Fragmental volcanic rocks subsequent in date to the strata among which they lie : of Tertiary age.

B. Intrusive or subsequent in date to the rocks among which they lie : of Tertiary, Carboniferous, Old Red Sandstone, Lower Silurian (?), and of uncertain age.

The most effective illustrations of geological structures are given in the ten plates which illustrate this memoir, and deserve special notice. Plate ii furnishes an admirable photo-reproduction of an exposure of contorted mica-schist with quartz-veins, seen in the shore-cliff opposite Imachar, two miles north of Dougrie, Arran. Plates iii and vi illustrate 'pillowy' structures in Arenig and Carboniferous lavas in Arran. Plates iv and v illustrate unconformability in Upper Old Red Sandstone and Lower Carboniferous rocks. The other plates illustrate false bedding in the New Red Sandstone, jointing in granite, a Tertiary dolerite dyke traversing New Red Sandstone, moraines in Glen Cloy, and a landslip.

This is a very full and interesting memoir, and contains, as will be seen from the title and introduction, contributions by many writers upon a great variety of subjects, although igneous and volcanic rocks and their microscopic structure occupy a large share of its pages. The appendices comprise: (1) Palæontology, by B. N. Peach, F.R.S.; (2) Petrography, by H. Kynaston and H. J. Seymour; (3) Bibliography.

The list of fossils have been prepared by Mr. B. N. Peach, Dr. C. B. Crampton, Dr. Traquair, Mr. Kidston, Dr. Wheelton Hind, Mr. E. T. Newton, and Mr. Tait. An index appropriately completes this very useful memoir on a most difficult and complex country, but one, upon which many geologists have expended their best energies to unravel and explore, from the days of Pennant (1794) and Hutton (1795) to Sir A. C. Ramsay, who made a model of the Island of Arran (in 1840–41), James Nicol (1852), Sir A. Geikie (1873 and 1897), and Wm. Gunn (1901–1903).

V.—AN OROGRAPHICAL SKETCH OF KOREA.

By B. Kotô, Ph.D. Rigakuhakushi, Professor of Geology, Science College, Imperial University, Tōkyō, Japan. [The Journal of the College of Science, Imperial University of Tōkyō, Japan, 1903, vol. xix, Article 1, pp. 62. 4to; 3 plates and large folding Geotectonic Map of Korea (plate iv).]

KOREA is an Asiatic kingdom, consisting mainly of a peninsula lying to the north-east of China, between 34° and 43° N. lat. and 124° and 131° E. long., being 600 miles from north to south and 135 miles from east to west, with an area of about 80,000 square miles. Its coastline is roughly estimated at 1,740 miles, and its size is slightly under that of Great Britain, with a population of 10,528,937.

"Korea," says Professor Kotô, "is the Italy of Eastern Asia. It stretches out from the main body of Manchuria in a southerly direction between the *cul de sac* of the Yellow Sea and the Sea of Japan, both being fringing seas, as Italy projects between the Adriatic and the Mediterranean.

"On the north and north-west the Korean peninsula is bounded by a well-defined topographic feature, the equatorial range of Chyang-păik-san, and a southerly lying basin drained by the Amnok-Gang[1] and the Tu-man-Gang.

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[1] This is the Ya-lu-Kiang of the Chinese and signifies the *duck-green river*, from the resemblance in the colour of the river water to that of a duck's neck. *Gang* or [illegible] signifies in the Korean language 'large,' and *chhyŏn mul* or *nai*, 'small' streams.

"Similarly, the peninsula of Italy is limited on the north l the Alps and the plain of the Po. Both peninsulas stretch abo 10 degrees meridionally; Korea from 33° to 43° North lat., Ita from 36½° to 46½°. They lie, as we have seen above, in near the same latitude of the Temperate zone, and enjoy an agreeabl transitional climate, neither too wet nor too dry. Both are inhabit by peoples of very ancient culture.

"However similar in their general outlines there are yet mar points of dissimilarity, especially in regard to their internal geologic components and structures and their external land forms. Italy not wanting in young geologic formations, while Korea is in tl main built up of Archæan and Palæozoic rocks. Though both cur a little to the east, Korea is mountainous on the side of the Sea Japan and rather flat towards the Yellow Sea, while in Italy tl Apennines run along the axis of the country.

"This Asiatic Italy, fitly called by W. E. Griffis the 'Land the Hermit Nation,' was secluded from the rest of the world f a long time, and even her old neighbours, the Japanese and tl Chinese, were strictly and vigilantly prevented from penetratin into the country. It is a unique patch of the earth's surface, a *ter incognita* in all respects, excepting eight free ports and the tw inland towns, where over 20,000 Japanese and men of oth nationalities have made themselves at home, but know nothing what lies a few kilometers from them in the interior. Only a fe Westerners have made trips into the country and studied the la and its people."

Lately, Professor Kotô twice made journeys in the peninsula, i 1900–1 and 1901–2, extending over 14 months, travelling over tl interior in a caravan with six men and four ponies, marchin 20 kilometres daily, and covering 6,300 kilometres in these trip crossing and recrossing the peninsula from one shore to the oth in nearly equidistant lines so as to enable him to obtain a gener idea of the land formation and geology of the country.

Professor Kotô found that only two previous explorers had ma reliable reports on the country, namely, Professor v. Richthofe and Dr. C. Gottsche, whose works serve to give a general idea the geography and geology of the peninsula.

Professor Kotô thus summarises his orographical sketch of Kor (p. 54):—"The Archæan formation, composed, as elsewhere, of gneis granite, gneiss, and mica-schists, is thrown into broad, undulatin folds on the front side of the peninsula, in the western portic of the Han-land and Paleo-Chyo-syön, becoming steeper as w go south. The axis of folding stretches from S.S.W. to N.N.E. from S.W. to N.E. Two prominent crests of this type are tl No-ryöng and Chhya-ryöng ranges, which extend obliquely acro Chyöl-la Do and Chhyung-chhyöng Do. Besides, many sma swellings of the crust surface can be seen in the Paleo-Chyo-sy Land, though deeply hidden under the mask of Paleozoic formatio Nearly half of the area of the peninsula is occupied by folds of th class. These specialized folds should be classed, according to n

view, with the Sinian System of South China . .
broad belt of the Sinian System which obliquely
Korean peninsula, if extended beyond the Tung-hai, wi
the mountains of South China, to which the name 'Sini
was originally given by Pumpelly."

Richthofen's ideal line runs from South Japan to]
then along the coast of Fokien and Kwang-tung,
H. Fischer's map of East Asia. (E. Debes' Neuer
No. 44.)

The greater portion of the Sinian System of Sout
which Ta-yü-ling forms the axis, enters the Tung-l
Fuchou and Shang-hai, and its further prolongation wil
well, both in its direction and its breadth, to those whi
to call the Sinian folds of Korea. If these Sinian folds
prolonged to the north-east, a greater part of the fold
unite directly with the tectonic lines of the Sichota-alin
given in Ivanow's work.[1]

The Sinian represents an old system of crustal f
peninsula, and contemporaneously with it, or a little late
generated another system in the Liautung direction in
Land, which was posthumously faulted in serial order
south, producing three parallel ridges (Myo-hyang-sa
ryŏng, and Kal-eung-nyŏng). These trend from W.S.W
and form apparently the direct continuation of South
Another line (the well-known Chyang-păik-san) st
and west, obliquely meeting the preceding in the l
Tu-man-Gang.

Professor Kotô names the complex of uplifted edge
times of folds, running in a north and south directio
axis of the peninsula, the 'Korean System.' It is so c
of this region that even native geographers long ag
its great importance in the surface features of th
This and many other minor groups are described and
detail by the author (on pl. iv), who also furnishes pr
in the text and nine process photographs (in three pl
views of the most striking features of the country.

Professor Kotô writes remarkably good English, a
graphical descriptions are interspersed with pieces of
about the people and the scenery of Korea. Here is
"Diamond Mountain, Keum-gang-san (1,200 metres =
is a large granitic stock [or intrusion] penetrating pal
It is excavated to its bottom by a crooked canyon
the precipitous walls of which overhang the bottom
a multitude of grotesque pinnacles; hence the mountai
called that of Twelve thousand peaks (Plate i, fig. 1). Tl
its steep slopes are forested with pine (*Pinus pinea*)
through which clear water rushes down in thousands
About 15 pagodas large and small have been her

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[1] "La chaîne du Sikhota-Aline," p. 112. Explorations géologiqu
long du Chemin de fer de Sibérie, Livraison xvi. St. Pétersbourg, 1

Sil-la period, some perched on rocky heads, some buried deep in the forest, giving shelter to world-renouncing monks and nuns. It is the Yosemite of the Korea, and a favourite resort of Westerners." (p. 18.)

"A high plateau, Kai-ma land, on the north has a precipitous front towards Manchuria; the incurves of Korea Bay on the west and of Chyo-syön Bay (Broughton Bay) on the opposite side give some idea of a boundary as expressed in coast lines, and we can trace it in the interior as well. In 1033 Tök-chong, the 9th king of Ko-ryö, ordered his subject Yu-syo to build a stone-wall 25 feet high and thick, across the peninsula so as to check the incursions of *Nuchens* and *Chitans* from the Manchurian frontier, perhaps after the model of the Great Wall of China constructed B.C. 220 by Shi-hwang-ti of the Tsin dynasty to ward off the inroads of *Hsiung-nu* from Inner Mongolia." (p. 32.)

"During my journey" (says Dr. Kotô) "I saw no continuous wall which might be looked upon as the ruin of this fabulous engineering work, but I frequently passed strong stone gates at strategically important points, such as at the foot and on the passes of the mountains. The Koreans are still very nervous because of their past sufferings, for they have to fear enemies from both north and south." (The northern enemy is not mentioned, but evidently Russia is hinted at! whose Siberian railway terminus is at Vladivostok, Amur Bay, long. 132° E., lat. 43° N.)

"From the south they have to guard against the encroachments of the Japanese. Travellers will see the towns fortified all along the south-coast, and in these intermural hermit-towns the people seek in vain a peaceful life."

It is quite evident that we shall hear more of the exploration of Korea within the immediate future.

VI.—ON BATRACHIAN AND OTHER FOOTPRINTS FROM THE COAL-MEASURES OF JOGGINS, N.S. By G. F. MATTHEW, LL.D., F.R.S.A. [Bull. Nat. Hist. Soc. New Brunswick, vol. v, No. xxi, 1903.]

IN this article are described some footprints of small Batrachians from the Nova Scotian Carboniferous. The largest is referred to King's genus *Thenaropus*, and compared with *T. heterodactylus*, King, and *Anthracopus ellangowensis*.

The two smaller tracks are referred respectively to Marsh's genera *Baropus* and *Dromopus*. They are well preserved, and show continuous series of footmarks. The first of the two has claws on most of the toes, but the second appears to have been devoid of claws.

There is also a track made by a small arthropod, which had a double series of claw marks on each side of the trail.

The species described in this paper are *Thenaropus* (?) *McNaughtoni*, *Baropus unguifer*, *Dromopus celer*, and *Myriapodites*, sp. A half-tone plate gives a good representation of these fossil footprints.

REPORTS AND PROCEEDINGS.

I.—THE GEOLOGICAL SOCIETY OF LONDON.

I.—May 27th, 1903.—Edwin Tulley Newton, Esq., F.R.S., Vice-President, in the Chair.

The Secretary read a letter from the President, expressing his regret that he would be unable to preside at the remaining meetings of the Session, as, in obedience to the orders of his doctor, he was obliged to take a complete holiday from all work for the next few weeks.

The following communications were read:—

1. "An Experiment in Mountain-Building." By the Right Hon. the Lord Avebury, P.C., F.R.S., F.G.S.

Various observers have endeavoured to throw light on the origin of mountains by compressing pieces of cloth, etc. In these cases, however, the pressure was only in one direction. The author wished to obtain a method of obtaining compression in two directions at right angles to one another; and, accordingly, he had an apparatus constructed, consisting of four beams of wood, which could be approximated by means of screws. In the space, 2 feet across and 9 inches in depth, were placed pieces of carpet-baize and layers of sand, each about 1½ inches deep. The beams were then caused to approach one another until the sand rose in the centre into contact with the glass cover, against which it was flattened out. Casts were made of the surfaces of the different baize-layers, and it was found that in the lower layers the ridges were narrower, shorter, more precipitous, and more broken up than in the higher layers. A second series of casts was exhibited, with the sand and baize having been arranged as before, but with the weight placed on one side. The ridges followed the edges, though not closely, leaving a central hollow. There was a difference between the higher and lower layers, similar to that seen in the first experiment.

2. "The Toarcian of Bredon Hill (Worcestershire), and a Comparison with Deposits elsewhere." By S. S. Buckman, Esq., F.G.S.

The Upper Lias (G 3) of Bredon Hill is shown on the Geological Survey map as more than 300 feet thick, whereas at Wotton-under-Edge it is said to be only 10 feet thick. But at the former locality the Inferior Oolite is represented as resting directly on Upper Lias, while at the latter the 'Midford Sands' intervene. It is shown that this 'Upper Lias' at Bredon contains strata of the following hemeræ:—*Lilli, Variabilis, Struckmanni, Dispansi, Dumortieriæ*, and *Moorei*, in addition to those of the hemeræ *Falciferi* and *Bifrontis*, which at Wotton have been called Upper Lias, where the rest have been mapped as the 'Midford Sand.' These sands are 210 feet thick, and hence the Toarcian strata of the two places are 220 and 380 feet thick respectively. Thus the so-called

'Upper Lias' is really the equivalent of the Upper Lias, Cotteswold Sands, and Cephalopod Bed of the Cotteswolds; of part of the Junction Bed, the Upper Lias, and Bridport Sands of the Dorset coast; and of the Toarcian of Normandy. Measured thicknesses of the strata at four localities in the Cotteswolds are given, and sections to show that an anticline was formed, and penecontemporaneous erosion took place at Birdlip before the *Scissi* hemera. A table of comparative thicknesses of deposits laid down during similar times in the Cotteswolds and Dorset is also given, and a section of the Toarcian at May-sur-Orne, and of the Toarcian and Aalenian strata at Tilly-sur-Seuilles (Calvados), where the Toarcian is reduced to a thickness of only some 23 feet. The chronometry of the Toarcian is discussed, and the approximate maxima of deposit formed during the hemeræ *Falciferi* to *Moorei* are given, amounting to a total of 719 feet. This time is divided into nine hemeræ, so that the time-value of a hemera is equal to the average time taken to deposit about 80 feet of strata. A concluding table gives the sequence and correlation of the following deposits:—The Cotteswold Sands, the Sands at Sodbury, the Midford Sands, those of Cole (Somerset), the Yeovil Sands, the Bridport Sands, and the Northampton Sands.

3. "Two Toarcian Ammonites." By S. S. Buckman, Esq., F.G.S.

Two Ammonites belonging to the family Hildoceratidæ, found by members of the Cotteswold Naturalists' Field Club, are described and named. The allies of both species have been figured in the "Monograph of Inferior Oolite Ammonites." One is near to *Denckmannia torquata*, but the degenerative change begins at an earlier age, and it soon shows marked decline of ornament of which that species gives little information. Its date of existence is probably hemera *Variabilis*. The other is a platygyral costate degenerative of *Chartonia binodata*; the inner whorls should be the morphic representations of that species, the outer whorls show a costate stage which is the general rule of decline from a tuberculate stage. Notes are given explaining the technical terms employed.

The Council have awarded the proceeds of the Daniel Pidgeon Fund for 1903 to Dr. E. W. Skeats, F.G.S., of the Royal College of Science.

II.—June 10th, 1903.—J. J. H. Teall, Esq., M.A., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "On Primary and Secondary Devitrification in Glassy Igneous Rocks." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., and John Parkinson, Esq., F.G.S.

Part I.—By John Parkinson, Esq.

In this part the types of primary devitrification as found at Obsidian Cliff are briefly reviewed, with the order in which they appear in the crystallizing glass. 'Porous spherulites' are once more mentioned, in order to call attention to the 'feather-like' crystals which often distinguish them, and of which an explanation is given in Part II. Reference is made to the conditions which favoured primary devitrification at Obsidian Cliff; and the author, leaving general principles to be discussed in the second part, mentions one or two special types of primary devitrification. These are concerned with the probable formation of eutectic zones, or patches; either following the crystallization of an overplus of any given material, or as a residuum. After a brief reference to secondary devitrification, this part of the paper concludes with a summary in which the several relations of secondary to primary devitrification structures are given.

Part II.—By Professor T. G. Bonney.

Crystallization in a colloid mass involves an orientation and commonly a separation of the molecules; a process illustrated in an early stage by the formation of microliths in a glass, and the devitrification of the latter when it is heated without actual melting, or by a metal becoming crystalline under strains. Certain conditions, such as slow cooling, supersaturation, and the presence of inclusions—anything causing discontinuity—are favourable to crystallization, some special cases of which are discussed in the paper. The structures thus formed in rocks may be classified as (1) the linear and (2) the granular; and the former may be subdivided into (*a*) the rectilinear, (*b*) the curvilinear. Spherulitic structure in its simpler form falls under (*a*), and is at first little more than a radial grouping of molecules, the process becoming, as described, gradually more complicated. Of this, 'graphic' or 'pegmatitic' structure is a final stage, where two minerals are crystallizing out of a solution, and one has slightly the advantage over the other, so that it virtually forms a skeleton crystal. Into this the ordinary radial growth of a spherulite may be seen to pass; likewise also examples of (*a*) into those of (*b*): the latter being due to the 'leading' mineral meeting with a rather stronger resistance, as if a crystal were forming in a very tough jelly. An experiment of Messrs. J. I'Anson and E. A. Pankhurst (Min. Mag., vol. v, 1884, p. 34) on the formation of tubes of colloid silica from a fluid alkaline silicate, affords a good illustration of this curvilinear growth. Resistances, as the author has pointed out in an earlier paper, are favourable to actinolitic and branching growths, and the various types of structure mentioned above can be shown to be dependent on them.

The granular structure is next discussed, and explanations are offered of its varieties. This, on a microscopic scale, is often a result of devitrification, where (so far as is known) there has been no marked rise of temperature; and the author shows how this is affected by greater or less freedom of molecular motion, discussing also cases in which a crystalline mass, like a spherulite, has undergone a later rearrangement.

In conclusion, the relation of some of the structures to an eutectic composition is discussed. It is not, however, easy, owing to the complexity of the conditions, to come to any very definite conclusions in the case of old rock-masses.

2. "Geology of the Ashbourne and Buxton Branch of the London and North-Western Railway: Crake Low to Parsley Hay." By Henry Howe Arnold-Bemrose, Esq., M.A., F.G.S.

The present paper is a continuation of one published in 1899, and deals with the geology of the next eight miles of this railway. After passing through Yoredale Shales in the second cutting (No. 10), the railway enters the thick beds of Mountain Limestone, in which it continues as far as Buxton. The latter rock is frequently folded, and owing to this no very great thickness of limestone is seen. It was not found possible to correlate the beds in the different cuttings. The following cuttings are described:— (9) Crakelow Farm, (10) Newton Grange, (11) Moat Low, (12) New Inns South, (13) New Inns, (14) Alsop-en-le-Dale, (15) Nettly Low, (16) Cold Eaton, (17) Cheapside, (18) Bank House, (19) Heathcote, (20) Hand Dales, (21) Caskin Low, (22) Lean Low, and (23) Parsley Hay; and measured sections are given of several of them, with an account of the folding and other features displayed. The Newton-Grange cutting shows 6 feet of tuff, probably a thin representative of the 140 feet seam in the Tissington cutting. The limestones are in places granular, oolitic, or dolomitized, and microscopical accounts are given of the several varieties, as well as of the encrinital limestones, pellets, and pebbles in the limestones, and the calcareous tuff.

II.—Mineralogical Society of London.

Mineralogical Society, June 9th.—Dr. Hugo Müller, F.R.S., President, in the chair. Mr. H. F. Collins gave an account of a remarkable mass of wollastonite with associated minerals which occurs at Santa Fe, State of Chiapas, Mexico. This mass of nearly pure wollastonite covers an area of 400 × 160 yards, and extends to a depth of more than 300 feet; it is surrounded on all sides by granite, felsite, and other igneous rocks, and is separated a mile from the nearest limestone. Near the outskirts of the mass occur extremely large crystals of wollastonite, most of which have been partially or entirely converted into quartz or semi-opal. Here are also found masses of garnet and of workable copper-ores containing gold and silver. The author exhibited and described specimens of wollastonite, bornite in wollastonite, bornite in chalcedony, gold-bearing linnæite, idocrase rock, and a remarkable intergrowth of bornite and galena resembling graphic granite.—Professor H. A. Miers gave an address, illustrated by lantern-slides, in which he described the extremely interesting results which he had obtained from the observation of the growth of crystals by a new method. The method consists in tracing the changes of angle upon a crystal during its growth by measuring it at intervals by means of a specially devised inverted goniometer, without moving it from the solution in which it is growing. It was found that a octahedron of alum yielded invariably three images for each face, so that the crystal had really the form of a very flat triakio-octahedron. Similar observations on other crystals lead to the conclusion that the faces of a crystal are in general not faces with simple indices, but vicinal planes slightly inclined to them, which change their inclination during the growth of the crystal. By determinations of the refractive index of the solution by means of total reflection within the crystal it was found that in each case the liquid in contact with a growing crystal is slightly supersaturated.

III.—Zoological Society of London.

Zoological Society of London, June 16th, 1903.—F. Du Cane Godman, Esq., D.C.L., F.R.S., Vice-President, in the Chair. Dr. A. S. Woodward, F.R.S., exhibited photographs by Dr. Otto Herz, illustrating the discovery and exhumation of a Mammoth in the Government of Jakutsk, Siberia. He also made remarks on the specimen, which has now been mounted in the Zoological Museum at St. Petersburg under the direction of Dr. Salensky.—Dr. H. Woodward, V.P.Z.S., F.R.S., read a communication from Miss Dorothy M. A. Bate giving a description of the remains of an extinct species of Genet from a Pleistocene cave-deposit in Cyprus, named *Genetta plesictoides*, n.sp., of which the following is an abstract:—In October, 1901, Miss Bate began her search for Pleistocene bone caves in the island of Cyprus, and in the following January first discovered Dikomo Mandra, a cave containing an extensive deposit of hippopotamus remains and the largest deposit of bones found in the Kerynia range of limestone hills in the north of the island. This proved to be the only cave in which the remains of any carnivorous animal were found, other than those of the fox still living in Cyprus. The remains consist of a left mandibular ramus, only lacking the second molar and canine and a few other bones. On comparing this ramus it appears to be that of a carnivore nearly allied to *Genetta genetta*, which is still found living on the opposite shores of Palestine. On the other hand, it also presents many similarities to *Plesictis Croizeti* of the Oligocene deposits of France. The Cyprus fossil agrees with and at the same time differs from both *Genetta genetta* and *Plesictis Croizeti*, and that so impartially that it is a matter of extreme difficulty to decide with which group it ought most properly to be associated. The scanty material adds to this uncertainty, which would probably be removed were the skull and upper dentition of this species known. However, in consideration of its much more recent age compared with that of the Oligocene fossil, it is proposed, at all events for the present, to include it among the genets under the name of *Genetta plesictoides*, n.sp. The mandibular ramus is intermediate in size between that of *G. genetta* and *P. Croizeti*, and the teeth also differ in several respects from both these species. The author has been unable to find a record of any fossil *Genetta*, and among the rest of the Viverridæ the only species of Pleistocene age appears to be *Viverra Karnuliensis* from India.

CORRESPONDENCE.

THE GEOLOGY OF BIARRITZ.

SIR,—In your pages of August last I described the reversal of Pyrenean geology at Lourdes and Biarritz effected by M. Carez in elaborate coloured sections of the *Bull. Soc. Geol.* for 1896, p. 379. By a typographical error, the map of the intermediate Pyrenees obtained from me by M. Carez in 1885 is referred to 1865. In spite of the studied condemnation of the reply of M. Carez to the geologist who had supplied his facts, I succeeded in re-establishing the Cretaceous age of the rocks represented as Middle Silurian and Cambrian, in which hundreds of Cretaceous Ammonites had been familiar to me for thirty years.

At Biarritz the supposed Lias, simultaneously figured in the same manner, has given birth to a unanimous selection of that locality as a type and proof of those Alpine paradoxes similarly created by MM. M. Bertrand, Carez, L. Bertrand, Bergeron, Seunes, and other officials of the French Survey. The question has been reduced to the decisive test of a boring of 104 metres deep, which boring has exactly proved the contrary of the views in question as figured by M. Bergeron in *Bull. Soc. Geol.* of 1900, p. 24. This boring has exactly confirmed my predictions of the same Bulletin, p. 614, as well as the detailed sections which I furnished to those interested at the Sorbonne. An elaborate attempt to explain away this decisive boring has been presented by M. L. Bertrand in *Bull. Soc. Geol.*, 1902, p. 83; and all his alleged facts have been refuted by M. Seunes in the *Compte Rendu* of the meeting of the same society on 6th April last.

The documents enumerated will enable any geologist to judge the method applied at Biarritz by the authors of the same paradox in the Alps, Montagne Noire, Provence, Corbieres, and such Pyrenean localities as Salies du Salat and Lasseube. Eight months of recent observation in the Alps, and repeated study of the other localities mentioned, have convinced me that Biarritz has been correctly selected by all the authors in question as a perfect sample of their work. The entire problem is precisely similar to that already settled at Lourdes.

In the hands of M. Seunes the problem attains the final stage of the process of proof invariably employed. This geologist is really familiar with the ground. In 1886 he was sent to me with a letter from the last two Professors of geology at the Sorbonne, begging me to supply him with my unpublished data, and promising that my published work should be the basis of his Thesis. Starting with all the new facts collected by my assistants and myself, he has completed his knowledge by yearly work. Consequently he has admitted, after 16 years, that every supposed fact cited as proving the presence of Trias at Biarritz is absolutely erroneous. Yet he affirms the correctness of the theory left standing on exploded fallacies alone. If he did not do so, his work would be treated as my own numerous papers, and as those in the *Bull. Soc. Geol.* of 1893 by the Staff

Officer who for ten years revised the topographical maps. That officer's practice in accurate mapping and my own practice in responsible engineering work compelled each of us to leave the Société Géologique when required to divorce theory from fact. Under Elie de Beaumont such divorce was inevitable, in the opinion of the new and exactly contrary school. Those trained to repeat either formula find the one as little embarrassing as the other. In all the localities already mentioned, I have found that admitted fallacies originated the paradoxes which survive. So at Biarritz the imagined Trias originates a fresh fallacy for each disproved. In the Alps, seven fresh paradoxes have already been imagined to justify the one found untenable by itself.

For more than thirty years I have been familiar with the presence of abundant gypsum, red marls, ophite, and granite in the Cretaceous to the south of Biarritz. The Trias theory rests entirely on their assumed absence. The intrusive granite has this year been exposed by extensive engineering works at St. Jean de Luz. In 1873 I took to Paris a conclusive series of specimens from the same point. Had I then presented them, I should have been boycotted from every society and periodical. I have found similar intrusions abundant in the analogous rocks of Italy, Switzerland, and Greece. But in the *Bull. Soc. Geol.* of 1902, p. 499, M. Carez again elaborately proves the absence of granite intrusions familiar to me along 200 metres just east of the bridge of Salies du Salat; and the source of M. Bertrand's speculations at Biarritz is the fact that he has described as exotic granite, at Lasseube, a common feature of the decomposing diabase of the Pyrenees. Palassou corrected the same blunder in 1819. The demand for local accuracy and experience was still active during my apprenticeship, and I owe to it whatever real information I possess. The present ideal is realized by the man who can describe an entire continent where he has never set foot. If any geologist without the taint of local knowledge, or the stigma of repeated success in quashing reckless assertion, would study the abundant literature of the Biarritz problem, he might do much to stem the torrent of garbled compilation that drowns all useful work in the most accessible of European chains. His observations might gain a hearing on the ground that their refutation should be easy. Mine are too well known to be unanswerable, and thereby only describable as polemics. That word, and the prompt substitution of one reckless fallacy for another, appears to console my opponents and satisfy their admirers. P. W. Stuart-Menteath.

St. Jean de Luz, *May* 5, 1903.

P.S.—On the road to Iholdy, at two kilometres south-west of St. Palais, the granite-like ophite, long known at Lasseube, can be seen rising from beneath extensive Upper Cretaceous; and many similar cases forbid the assumption of superficial carting where the relations are obscure. The nature of the Biarritz problem can be understood from my map in *Comptes Rendus de l'Académie des Sciences* of June, 1894.

THE CHART OF FOSSIL SHELLS FOUND IN CONNECTION WITH THE SEAMS OF COAL AND IRONSTONE OF N. STAFFORDSHIRE.

SIR,—In reading Mr. Walcot Gibson's review[1] I was astonished to see it stated that "marine organisms are represented as occurring on three horizons," and also that the marine band above the Gin Mine has been omitted.

Writing with the Chart before me, and having personal knowledge of the bands, I should like to correct what seems to me an unaccountable error on the part of Mr. Walcot Gibson, who is usually so accurate in his statements. The fact is that eight distinct and separate marine bands are denoted, and moreover the Gin Mine is represented by figures.

The following are the horizons represented on the Chart as marine beds, viz.:—

1. Bay Coal Band.
2. Priorsfield Band.
3. Gin Mine Band.
4. Single Two Feet or Moss Cannel Band.
5. Weston Sprink Band (horizon doubtful).
6. Seven Feet Banbury Band.
7. The Wetley Moor Coal Band.
8. The Four Feet or Crabtree Band.

I should like to call attention to another point, to which I should have expected Mr. Gibson specially to have referred. Various attempts have been made to correlate the seams of the several districts of this coalfield, generally on lithological or sequential evidence. On this Chart the seams of the whole coalfield have been successfully correlated for the first time, the marine bands forming sure data lines.

E. P. TURNER.

ASHWOOD TERRACE, LONGTON, STAFFS.
25th May, 1903.

OBITUARY.

SAMUEL CHADWICK.

BORN 1845. DIED MARCH 18, 1903.

THE death is announced of Mr. Samuel Chadwick, who was one of the founders of the Malton Field Naturalists' Society, and devoted many years to the collection of fossils from the Jurassic and Cretaceous formations of East Yorkshire. He left his native county early in life to engage in sheep-farming in New Zealand, but he returned after a few years and resided for a long period at Malton, where his business afforded him numerous opportunities of prosecuting the geological studies in which he was deeply interested. His early colonial experiences led Mr. Chadwick to emigrate again to New Zealand with his family in 1895, and he died suddenly last March at Moastone Park, Waikopiro. His remarkable collection of fossils is now in the Malton Museum, and contains many unique specimens, of which a large proportion still remain to be studied and described. He discovered a considerable series of Calcisponges in the Corallian of Malton. and these were described by Dr. G. J. Hinde in his Monograph of British Fossil Sponges (Palæont. Soc.). One new species was named *Corynella Chadwicki*. He also discovered various fish-remains, which have been noticed in papers by Dr. Smith Woodward. For several years Mr. Chadwick was a Fellow of the Geological Society.

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[1] GEOL. MAG., May, p. 226.

MISCELLANEOUS.

MATHEMATICAL CRYSTALLOGRAPHY.—The Oxford University Press has just issued "Mathematical Crystallography" by Mr. H. Hilton, whose object has been to collect for the use of English readers those results of the mathematical theory of crystallography which are not proved in the modern textbooks on that subject in the English language.

THE GEOLOGICAL AND MINERALOGICAL SURVEY OF CEYLON.—We are pleased to learn that DR. ANANDA COOMÁRASWAMY, F.L.S., F.G.S., has lately been appointed Director of the newly created Mineral Survey of Ceylon, the headquarters of which are at Peradeniya; and Mr. James Parsons, B.Sc., F.G.S., has been made Assistant Surveyor.

SOUTH AUSTRALIA.—Mr. H. Y. L. Brown, F.G.S., has issued a report (1902) on the White Range gold-mines of the Arltunga Goldfield, in the northern territory of South Australia. This is purely economic. With it, however, come Nos. 12 and 13 of the "Contributions to the Palæontology of South Australia," 1902, a single folio tract by Robert Etheridge, jun., containing "More complete evidence of *Thinnfeldia odontopteroides*, Morris, in the Leigh Creek Coal-measures," and "Evidence of further Cambrian Trilobites." The species of Trilobites come from 40 miles S.E. of Elkedra, a deserted cattle station, in lat. 21° S., long. 135° 22′ E., approximately. This place is 150 miles south of Alexandra, where *Olenellus Browni* was obtained, which Etheridge described in 1897. The specimens are referred to a new *Agnostus* (*A. elkedraensis*) and a new *Microdiscus* (*M. significans*).

QUEENSLAND.—Bulletin 18 (171 of the publications) of the Geological Survey of Queensland contains "Fossil Plants from Duaringa, Ipswich, Dawson River, and Stanwell," and "Fossil Wood from the Ipswich Beds, Boggo Road, Brisbane," by John Shirley. These papers illustrate the Palæozoic and Mesozoic floras, and figures are given of the forms described. No. 179, Geological Survey Report, by Lionel C. Ball, deals with Yorkey's Goldfield and the Marodian Gold and Copper Field, 1902. This is mainly economic, but contains notes on the petrology of the country.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. VIII.—AUGUST, 1903.

ORIGINAL ARTICLES.

I.—NOTES ON AN EXPEDITION TO THE FAYÛM, EGYPT, WITH DESCRIPTIONS OF SOME NEW MAMMALS.

By C. W. ANDREWS, D.Sc., F.G.S.

IN the following note I propose to give a brief account of the chief results obtained during an expedition to the Fayûm in the early part of the present year (1903). The localities in which collections were made lie to the north of the lake Birket-el-Kerun, and are almost the same as those examined on previous occasions. Practically nothing was found in the Middle Eocene beds, but from those of Upper Eocene age a fairly large collection of vertebrate remains, including several new forms, was obtained. A few interesting things were also found in the Quaternary lake-beds in the neighbourhood of Schweinfurth's Temple (Qasr-es-Sagha); these will be referred to more fully below.

In the Upper Eocene bed the commonest forms appear to be *Palæomastodon* and *Arsinoitherium.* Of the former the greater part of a skull was found, showing that in cranial structure as well as in the teeth this animal was a far more generalised mammalian type than the later elephants. For instance, although the occipital region closely resembles that of the elephant in essential points of structure, nevertheless the enormous development of cellular bone which gives the posterior portion of the elephant skull its peculiar and characteristic appearance, has only just begun, and the temporal fossæ are only divided from one another by a high sagittal crest which extends forward to a point a little behind the orbits. The *basis cranii* and the facial region of the skull are much more prolonged than in the elephant, though here again there are no differences in essential structure. Another peculiarity noticed in the remains of *Palæomastodon* is the great variability in the dimensions, even among adult individuals. When it is remembered that this animal is probably the transitional stage between the small *Mœritherium,* about the size of a tapir, and the large longirostrine Mastodons, this variability in size is particularly interesting as supplying the basis upon which selection could bring about a rapid increase in the dimensions of these early proboscideans, and, indirectly, give rise also to the remarkable series of changes (described elsewhere) which culminated in the production of that characteristic structure in this group, viz. the prehensile trunk.

This year remains of *Mœritherium* have been found in the Upper Eocene, a fine skull having been collected by Mr. Beadnell and a good set of lower teeth by me. It is probable that the species is distinct from those found in the beds below, in which, it should be noted, no trace of *Palæomastodon* occurs.

A considerable series of remains of *Arsinoitherium Zitteli*, Beadnell,[1] was obtained, one of the most important specimens in the whole collection being a fine skull and mandible, the first, as far as I am aware, that have been found in actual association. Furthermore, evidence of the existence of two other species of the genus has been discovered. One of these was a much smaller form, and is represented only by a portion of the upper dentition, but the other was a considerably larger animal. For instance, the dimensions of a fine left ramus of the mandible are in the proportion of about four to three of those of the mandible of *A. Zitteli.* The teeth in this jaw are excellently preserved, and the premolars present some peculiar features. The maxillary teeth as well as some vertebræ and limb-bones of the same individual were also collected.

The occurrence of a large Hyracoid belonging to a new genus (see description below) is noteworthy. Already two species named *Saghatherium antiquum* and *S. minus* have been described,[2] and I am acquainted with fragmentary remains of at least two other species, one of which belongs to a third genus. The presence of five Hyraces in these beds indicates that these animals must at that time have been an important factor in the fauna, and that the comparatively small members of the group now existing are the degenerate descendants of a once important stock. At least, one large species, *Pliohyrax græcus*, is known to have persisted till the Lower Pliocene, and has been found in beds of that age in Samos and Pikermi. As remarked below, the Egyptian species are already similar to the recent forms both in the structure and arrangement of their teeth, so that we seem as far as ever from finding a clue to their exact relationship to other ungulates.

The mandibular ramus of a large Creodont is described below and referred to a new species of *Pterodon.* It is worthy of note that *Ancodus* and *Pterodon* seem to be the only two genera of mammals found in these beds (so far as at present known) which also occur in pre-Miocene beds in Europe. Fragmentary remains of at least two smaller species of Creodonts were also found.

No new Reptilia were found, and the only specimen of value collected was a fairly complete carapace and plastron of the gigantic land tortoise *Testudo ammon*, a preliminary note[1] on which by Mr. Beadnell and myself has lately appeared.

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[1] "A Preliminary Note on *Arsinoitherium Zitteli*," by H. J. L. Beadnell, Survey Department, Cairo, 1902.

[2] "A Preliminary Note on some New Mammals from the Upper Eocene of Egypt," by C. W. Andrews & H. J. L. Beadnell, Cairo, 1902.

Several visits were paid to the lake-beds in the neighbourhood of Schweinfurth's Temple (Qasr-es-Sagha) and Dimé (see map given by Beadnell on p. 55 of this volume), and numerous flint implements such as have been recently described[2] from this locality were collected. In the same beds as these a femur and a posterior molar of an elephant were also found. The femur is that of a very large individual; it is incomplete at its upper end, the neck having been weathered away. Its length when whole was approximately 134 cm. (4 ft. 5 in.), and the diameter of the narrowest part of the shaft 39·5 cm. (15½ inches); the diameter of the head was about 17·5 cm. All the characters of the bone point to its belonging to *Elephas africanus*, a conclusion confirmed by the tooth, which is a much worn (?) last molar. The occurrence of elephant remains in this locality associated with the flint implements is important, both as extending the known range of the African elephant and also as supplying a strong reason for regarding the implements as being of prehistoric age. Dr. Budge informs me that no representation of the elephant occurs on any of the early Egyptian monuments, which certainly would not have been the case had the artists been familiar with the animal, and it therefore seems that it became extinct in Egypt at some prehistoric period, when also the implements accompanying its remains must have been made. In these beds also bones of *Hippopotamus* are very common, and those of antelopes fairly numerous; a horn-core of a species of *Bubalus*, probably *B. lelwel*, was found; remains of this species have been found in tombs at Abadiyeh.

The physical conditions of the district when the lake spread over a much larger area than at present must have differed considerably from what we now see. In addition to the widespread occurrence of remains of a thick growth of tamarisk bushes, in some places considerable areas are covered with the stumps of fossilised trees, sometimes of fair size.

Description of two New Species of Mammals.

One of the most interesting finds made on this occasion is the left maxilla, with the teeth, of a very large hyracoid mammal which must have been about the size of a large tapir. The maxillary teeth (including the canine) form a continuous, slightly curved series, and increase regularly in size from before backwards. The most notable character of the cheek-teeth, as a whole, is the presence of a well-defined channel for the reception of the crowns of the mandibular teeth, running from end to end of the molar and premolar series, and dividing their crowns into approximately equal inner and outer portions. Part of the outer side of m. 1 and 2 and nearly the whole of the outer half of p.m. 4 are broken away; the portions missing are left unshaded in the figure.

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[1] "A Preliminary Notice of a Land Tortoise," by C. W. Andrews & H. J. L. Beadnell, Survey Department, Cairo, 1903.

[2] H. J. L. Beadnell, "Neolithic Flint Implements from the Northern Desert of the Fayûm, Egypt": Geol. Mag., Dec. IV, Vol. X (1903), p. 53, Pls. III–IV.

The crowns of the brachydont molars are quadrate in outline; their outer wall is formed by a W-shaped ectoloph composed of the following elements:—a large and prominent parastyle (*p.*) and mesostyle (*ms.*) and a less-marked metastyle (*mt.*) united by V-shaped paracone (*pa.*) and metacone (*me.*). On the posterior face of both the parastyle and mesostyle is a small but well-defined tubercle, marked × in the figure; these tubercles seem to belong to the cingulum. The inner half of the tooth is composed of two tubercles, the protocone (*pr.*) and hypocone (*h.*), which give a V-shaped pattern in wear, and the anterior arms of the V's, which are the longer and may include traces of the protoconule and metaconule respectively, run outwards towards the parastyle and mesostyle. In the last molar only there is a small hypostyle (*hy.*). M. 2 and m. 1 are similar to m. 3, except for the absence of the hypostyle and their smaller size.

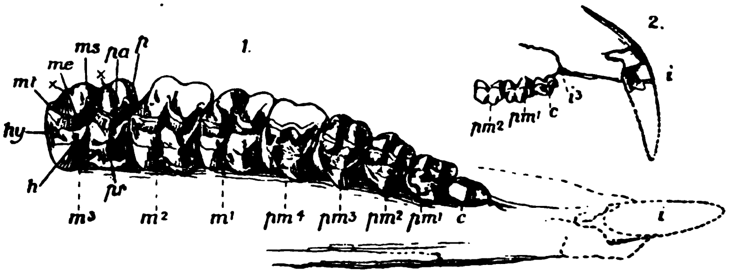

FIG. 1.—Upper dentition of *Megalohyrax eocænus*, gen. et sp. nov. The premaxillary region with the incisor (*i.*), shown by dotted lines, is provisionally restored from a premaxilla referred to in a former paper as possibly that of *Phiomia*. One-third nat. size.

FIG. 2.—Front of upper jaw of *Saghatherium antiquum*, And. & Bead, showing enlarged incisor. One-half nat. size.

c. canine; *h.* hypocone; *hy.* hypostyle; *i.* first incisor; $i.^3$, third incisor; $m.^{1-3}$, molars; *me.* metacone; *ms.* mesostyle; *mt.* metastyle; *p.* parastyle; *pa.* paracone; $p.m.^{1-4}$, premolars; *pr.* protocone.

In the fourth premolar the outer half of the tooth is broken away, but the inner portion is well preserved. This tooth differs from the first molar in the much smaller size of the hypocone (using the same nomenclature as for the molars), which is reduced to a small cusp situated on the extreme postero-internal border of the tooth. In p.m. 3 the hypocone is still smaller, and in p.m. 2 it is entirely absent. P.m. 1 is relatively more elongated than p.m. 2, the protocone is smaller, and there is a small postero-internal cusp on the cingulum which may represent the hypocone. In the premolars the ectoloph seems to consist of the parastyle, the paracone, and the metacone only; but in the posterior premolars there is a small cusp on the cingulum which may represent the mesostyle.

The canine is an elongated two-rooted tooth immediately in front of the anterior premolar and in the same line. Its crown consists of a single low cusp, on the inner side of which there is a fairly well-developed cingulum. There is no distinct alveolus for the third incisor immediately in front of the canine, as in *Saghatherium* (Fig. 2).[1]

Comparison of the dentition just described with that of the much smaller *Saghatherium antiquum* shows that in nearly all important points in the structure of the teeth the two agree; on the other hand, the absence of the incisor in front of the canine, as well as the much greater size, seem to justify the generic separation of this species, for which the name *Megalohyrax eocænus* is proposed.

The discovery of this large Hyracoid throws much light on several doubtful fragments previously collected by Mr. Beadnell or myself. For instance, there is little doubt that the remarkable premaxilla bearing a long pointed tusk, triangular in section, provisionally referred to *Phiomia* in the paper above cited, belongs to the present species, and in the figure I have had it sketched in in outline to show its probable position with regard to the maxilla here described (Fig. 1). The reason for adopting this view is that in a specimen of the upper dentition (Fig. 2) of *Saghatherium antiquum* in the British Museum the front of the premaxilla is occupied by a precisely similar tusk-like incisor (*i.*); and since, as already mentioned, the molars of this species are closely similar to those of *Megalohyrax eocænus*, it is at least probable that the latter also possessed a similar tusk, a supposition fully confirmed by the occurrence in the same beds of the remarkable specimen referred to, which corresponds both in size and form to what might be expected to have existed. It should be noted that these tusk-like incisors, both in shape and in the arrangement of the enamel, agree closely with those of *Procavia dorsalis*,[2] and it is a very remarkable fact that this peculiar specialisation of the incisors in the Hyracoidea had already arisen in the Upper Eocene.

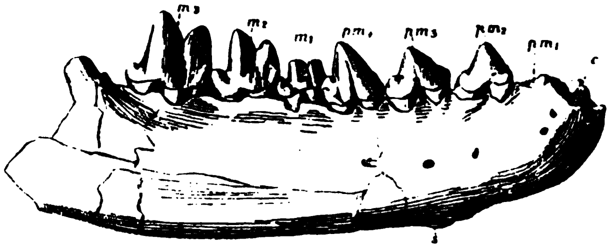

FIG. 3.—Right ramus of mandible of *Pterodon africanus*, sp.n. *s* marks posterior end of symphysis. One-third nat. size.

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[1] "A Preliminary Note on some New Mammals from the Upper Eocene of Egypt," by C. W. Andrews & H. J. L. Beadnell, Cairo, 1902.

[2] That is to say, that the tooth is long, curved, and grows from a persistent pulp; in section it is triangular, one of the angles being anterior. The two anterior faces only are enamel covered, and the tooth wears to a sharp point.

The dimensions of the type-specimen (Fig. 1) are:—

	Length.	Width.
m. 3	37 mm.	35 mm.
m. 2	37 ,, (approx.)	32 ,,
m. 1	30 ,,	25 ,,
p.m. 4	—	19 ,,
p.m. 3	25 ,,	21 ,,
p.m. 2	23 ,,	18 ,,
p.m. 1	18 ,,	18 ,,
c.	18 ,,	12 ,,

Total length of the molars	86 mm.
Total length of the premolars	76 ,,
Total length of the cheek-teeth, including the canine	178 ,,

Another interesting new species is a large Creodont, the type-specimen (Fig. 3) of which is the greater part of the right ramus of a mandible, about the size of that of a large bear. The molars and the last three premolars are in a perfect state of preservation, but the first premolar, the canine, and two incisors are represented by their empty alveoli only. Anteriorly the bone is complete, but posteriorly it is broken off about an inch behind the last molar. The symphysial region extended back to the level of the front of p.m. 3 (Fig. 3, *s*), and is very massive owing to the great size of the canines. The ramus remains nearly the same depth throughout its length, widening only very slightly beneath the hinder molars. The last molar, which is the largest of the series, is a high-crowned cutting tooth composed of two blade-like cusps and a small talon. The posterior of the two cusps is the higher, and it bears a sharp keel-like ridge on its postero-internal surface; on the antero-external surface of the anterior cusp there is a small tubercle which seems to belong to the cingulum. M. 2 is similar, but has a larger talon with a cutting edge. The first molar, which is the smallest of the cheek-teeth, is also generally similar, except that the main cusps, which are much worn, seem to be less compressed. P.m. 4, which is much larger than m. 1, consists of a large conical, rather backwardly directed main cusp, with a sharp keel-like cutting edge on both its anterior and posterior borders; behind this is a small talon, and on the whole of the inner side of the tooth there is a fairly developed cingulum, which rises into a small cusp both in front and behind. In p.m. 3 the main cusp is shorter and blunter than in p.m. 4, and the talon is smaller. P.m. 2 consists of a single cusp, the anterior border of which is much shorter than the posterior. The first premolar is represented by a small alveolus only.

The canine must have been very large, and was oval in section. There were two incisors, which, in consequence of the large size of the canine, do not stand side by side in the usual manner, but are placed one above the other in a vertical plane.

There are two large foramina on the jaw, one beneath p.m. 4, the [illegible] beneath p.m. 3. In addition to these there are also two small [illegible] foramina in the inflated sides of the canine alveolus.

[illegible] dimensions of this specimen (Fig. 3) are:—

	cm.
Total length of the specimen as preserved	23·8
Length of the symphysis	8·6
Depth of the ramus opposite the hinder end of the symphysis ...	5·5
Depth of the ramus beneath m. 2	5·8
Depth of the ramus beneath m. 3	5·7
Transverse diameter of the canine alveolus (approximate)	2·0
Antero-posterior diameter of the canine alveolus (approximate) ...	2·7

Dimensions of the teeth:

	Length.	Width.
p.m. 2	23 mm. ...	11 mm.
p.m. 3	26 ,, ...	13 ,,
p.m. 4	26 ,, ...	13 ,,
m. 1	21 ,, ...	10 ,,
m. 2	28 ,, ...	14 ,,
m. 3	34 ,, ...	17 ,,

This animal closely resembles *Pterodon dasyuroides*, De Blainville, described and figured in detail by Filhol and Gervais, and may be referred to the same genus. On the other hand, its large size entitles it to specific distinction, and the name *Pterodon africanus* may be suggested for it.

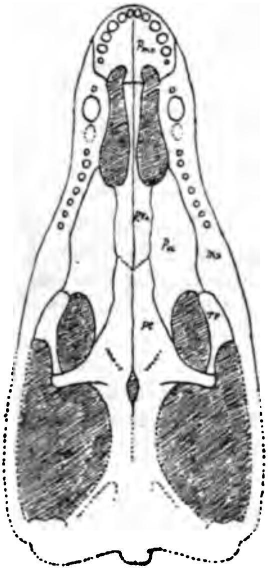
II.—On the Structure of the Palate in the Primitive Theriodonts.

By R. Broom, M.D., B.Sc., C.M.Z.S.

FOR some years it has appeared to me that in the Order Theriodontia as generally accepted there were included a number of forms not at all nearly related to the typical genus, *Galesaurus*, and in a number of papers I have referred to these as 'Primitive Theriodonts.' The best known genera are *Ælurosaurus* and *Ictidosuchus*, but as in neither of these have the details of palatal structure been very clearly made out, it has been impossible to say how far they differed from the typical Theriodonts.

Having recently, at the request of Mr. W. L. Sclater, made an examination of some of the reptilian fossil remains in the South African Museum, I came across one or two interesting small Theriodont skulls that had been for many years in the Museum. These will be described in detail in the *Annals* of the Museum; but as one of the skulls, when developed, shows the almost perfect palate, I have thought it advisable to issue this short note on the subject, as the discovery fills a most important gap in our knowledge.

The little skull which bears some resemblance to *Ælurosaurus* I have named *Scylacosaurus Sclateri*. While there is nothing remarkable about the structure of the skull as viewed from above or the sides, the dentition is interesting. In each premaxillary bone there are six incisors, of which the last is very small. Each maxillary has a large tooth near the front, which is evidently a canine. It is not, however, the first of the maxillary teeth, as in front of it, and undoubtedly implanted in the maxillary bone, is a small pointed tooth. I regard this minute tooth as the 1st canine and the large tooth as the 2nd canine. There is evidence of a third tooth, as yet immature, as large as the second, and which I regard as the 3rd canine. Behind the 3rd canine are seven small simple molars. A minute canine in front of the large canine is figured by Owen in *Gorgonops*, and it also occurs in another genus (*Ictidosaurus*), which I am describing.



Restoration of Palate of *Scylacosaurus Sclateri*. × ·45.
Mx, maxilla; *Pa*, palatine; *P.mx*, premaxilla; *Pt*, pterygoid; *P.vo*, prevomer; *T.p*, transpalatine.

The palate is quite unlike that of *Galesaurus* and *Cynognathus*, and is only a slight modification of that found in the Rhynchocephalians and most other primitive reptiles. It will be more readily understood by reference to the Figure than by description. The internal nares are situated well in front, and divided by the paired 'vomers,' or, as they perhaps had better be called, prevomers. These prevomers are of considerable size and form a large part of the hard palate, and articulate posteriorly with the pterygoids. The palatines articulate with the maxillaries along a line a little to the inside of the molar teeth, and partly enter the posterior border of the internal nares. The pterygoids are of large size. In front they pass forwards between the palatines to meet the prevomer, and form a large part of the hard palate. They have well-developed transverse processes, which are supported by rather slender transpalatines or ecto-pterygoids. The posterior part of the palate is unknown, but is probably as restored in the Figure.

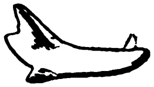
As the palate of *Scylacosaurus* and its allies differs so very greatly from that of the typical Theriodonts I have proposed to constitute a new order — the Therocephalia — for the primitive Theriodonts. There are many other points of difference between the two groups which I have dealt with in the paper above referred to.

Not improbably the Theriodonts proper are descended from the Therocephalians, but the gap between the two is probably as great as between Parasuchians such as *Phytosaurus* and the Crocodiles.

III.—On the Lower Jaw of a small Mammal from the Karoo Beds of Ariwal North, South Africa.

By R. Broom, M.D., B.Sc., C.M.Z.S.

In the collection of Mr. Alfred Brown, of Ariwal North, which I had recently the pleasure of looking over, I came across the right lower jaw of a small mammal which Mr. Brown had discovered in sandstone near Ariwal. Though unfortunately the teeth are lost, there is evidence of there having been a large canine. The most remarkable character of the jaw is its extreme shortness, and in its general proportions it agrees much more with the jaws of some of the small carnivorous Eutherians than with those of the small carnivorous or insectivorous genera already known from the Secondary rocks. The angle is well developed and but very slightly inflected. The condyle is practically in a line with the alveolar margin.



Lower Jaw of *Karoomys Browni*. Nat. size.

In the absence of the teeth it is impossible to say much regarding the affinities of the genus. It is not improbable, however, that it is a member of the primitive mammalian group which gave rise to the Marsupials on one hand and the Eutherians on the other. Its nearest known allies are probably to be found among the Jurassic forms such as *Diplocynodon* or *Docodon*.

I propose to call the new form *Karoomys Browni*, after the discoverer, who has already enriched science by the discovery of so many new forms.

IV.—The Minerals of some South African Granites.[1]

By F. P. Mennell, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

Plutonic rocks of acid composition are very extensively developed in Africa south of the Equator. These rocks present many features of interest, and, especially under the microscope, many minerals may be recognized besides the usual quartz, felspar, and ferromagnesian constituents. Thus the granite of Cape Town itself is remarkably rich in accessories. Tourmaline, in particular, is very abundant in places. In thin sections it is of a yellowish brown colour frequently bordered and zoned with pale blue, while some crystals show alternate bands of yellow and brown. Cordierite also appears to be sometimes present in the normal granite. It may be quite fresh and almost indistinguishable from quartz, while in other cases it is entirely replaced by the yellowish micaceous 'pinite' pseudomorphs. The intermediate stages of the alteration are well shown, while it is interesting to note that it seems to have crystallized sometimes before and sometimes after the felspar. The mineral is most often found in the basic patches of the granite, which are no doubt derived from the fusion and subsequent recrystallization of fragments of the adjacent slate, and are especially interesting. Some are largely made up of andalusite in good crystals or somewhat rounded grains, with abundant strongly pleochroic biotite, and a certain amount of quartz, felspar, muscovite, tourmaline, cordierite, and apatite. Both the patches and the normal rock also contain numerous small zircons, generally as inclusions in the biotite, where they give rise to the usual intensely pleochroic 'halos.'

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[1] Read before the South African Association for the Advancement of Science, April 28th, 1903.

In the Tati district of Bechuanaland granite occurs as a modification of the prevailing syenite, and is chiefly remarkable for the amount of apatite it contains. I have seen crystals of this mineral from Tati nearly an inch in diameter; but in the rocks I have examined they are of purely microscopic dimensions. They show not only the usual cross-fracture, but also complete dislocation of single crystals into a number of separate fragments divided by portions of the enclosing quartz or felspar. Sphene is abundant in this rock. It surrounds the iron ores in whitish granular aggregates, which, unlike the variety leucoxene, are more or less transparent and show brilliant interference tints when the sections are sufficiently thin.

The granites of Rhodesia are notable for the abundance of microcline, which is frequently the dominant, and sometimes the only, felspar. The now well-known Matopo granite is typically composed of microcline, quartz, and biotite, with minute granules of magnetite and sparingly distributed but large crystals of brownish sphene. The Bulawayo margin of the mass is a hornblende granite with microcline, oligoclase, and orthoclase as the felspars. The accessories include large crystals of apatite, abundant yellowish sphene, a little magnetite, and sometimes a good deal of pale yellow epidote. The last-named mineral occurs in druses, and forms veins running through the granite in places. Large plates of biotite are found in the pegmatitic modifications, with microcline, etc. Fluor, malachite, chessylite, and chrysocolla occur lining cracks and joints, while molybdenite is found associated with a little secondary copper pyrites, etc., in a quartz segregation vein near Glenville, about three miles from Bulawayo. This mineral is in good crystals, thin hexagonal plates looking as if bounded by the prism and basal plane. Careful measurements of the angles give no appreciable difference from 120°, though only two of the lateral faces appear as a rule to be normal to the basal plane. They appear, in fact, to possess orthorhombic symmetry, and to be really bounded by the pyramid, brachypinacoid, and basal plane.

Several of the granites from Northern Rhodesia contain orthite (allanite). This mineral occurs in yellowish-brown idiomorphic crystals or rounded grains, the colour being sometimes very irregularly distributed. The pleochroism is not strong, and the double refraction as a rule scarcely exceeds that of quartz. A rock from the Jibuyi River contains numerous crystals about ·5 to 1·5 mm. in length, occasionally twinned, and showing inclusions of zircon, apatite, and magnetite. The orthite is usually surrounded by epidote with more or less irregular outlines. The two minerals do not extinguish simultaneously, but that they are intergrown in definite crystallographic relation is shown by the fact that if the outline of suitable orthite crystals is taken as indicating the orientation of the surrounding epidote, the latter is found to give straight extinction. A biotite-hornblende granite from Kalomo shows zoned orthite surrounded by epidote with good crystal outline, the latter being enclosed in turn in biotite. Minute crystals of orthite also occur enclosed in the mica, where they give rise to halos which resemble but are not quite so strongly pleochroic as those which usually surround zircon. Epidote is extraordinarily abundant, and there is a good deal of sphene. A gneissose rock from the Wankie District of Matabeleland, with orthoclase crystals several inches across, presents some special points of interest. Little pink garnets and minute brown granules, which are seen under the microscope to be orthite, can be detected by the unaided eye. The garnet is in the larger grains, but the orthite is much more abundant. It is rather more strongly pleochroic than in the rocks previously mentioned. It shows zonary banding, and is frequently surrounded by biotite, but no epidote is present. The rock contains much apatite. All these orthite-bearing rocks have a distinctly gneissic aspect, which is sufficient to suggest a secondary or metamorphic origin for the orthite, even apart from its association with epidote. The presence of garnet appears to point in the same direction. It may be remarked, however, that all the rocks are exceptionally fresh, while those from Northern Rhodesia contain micropegmatite, a fact which appears absolutely conclusive as to their igneous origin. The fact of the epidote being idiomorphic towards the mica points, moreover, to its primary nature, as do the inclusions of apatite and magnetite, with zircon as well in the case of the orthite, which alone encloses recognizable crystals of that mineral. It may also be mentioned that the fine-grained modifications of the Jibuyi rock contain correspondingly small crystals of orthite, and we seem accordingly driven to regard both orthite and epidote as normal products of the consolidation of a molten magma.

V.—Contributions to Ceylon Geology:

Occurrence of Corundum *in sitú* near Kandy, Ceylon.

By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director of the Mineral Survey of Ceylon.

THE present notes are based on field observations made in 1900. The section described is now obscured.

Corundum is abundant in the gem-bearing gravels of Ceylon, but with the exception of the case here described no localities are known where it occurs *in sitú*; the present occurrence is therefore of considerable interest, although not very satisfactory in itself.

Crystals of corundum were found in the surface soil on a piece of land known as Tenna Hena, and situated east of Kandy, and three-quarters of a mile north-east of Talatnoya bridge. The exact spot is shown in a map accompanying a paper on the crystalline limestones of Ceylon (Quart. Journ. Geol. Soc., 1903, vol. lviii, pl. xiii). A small excavation had been made, and a few pounds of corundum extracted and sold for use as emery, before my visit to the spot. All the rock exposed was decomposed, and crumbled in the fingers, being in a condition resembling sand.[1] I therefore carried on an excavation for two months, hoping to reach hard rock suitable for microscopic examination, but although a depth of about 30 feet was reached, no sufficiently hard rock was found.

At the corundum pit the 'beds' of granulite dip northwards at a high angle. A conspicuous soft yellow micaceous band 7–3½ inches wide marks the position of the sapphire-bearing zone. The sapphires occur in fair abundance in a less decomposed felspathic rock occupying a few inches on either side of this yellow micaceous band in the upper part of the shaft, but on the south side only in the lower part. The associated types of granulite are chiefly acid leptynite. The corundiferous band is about three yards from the northern boundary of a band of crystalline limestone about seven yards wide (in the lower part of the pit the distance was apparently less). There is nothing to suggest any connection between the occurrences of corundum and limestone. It is a little strange that corundum has not so far been found in the crystalline limestones of Ceylon, although so characteristic of similar rocks in Burmah.

The sapphires are of fair size, the largest about three quarters of an inch in diameter, and though of a bright blue colour, are useless as gems owing to their opacity and well-developed cleavage, and often weathered, bleached, and hydrated condition. Rhombohedral cleavage and a basal parting are alike well displayed. Combinations of the hexagonal prism and basal plane are most usual, giving a columnar aspect; the forms observed include *c* (0001), *a* $(11\bar{2}0)$, *r* $(10\bar{1}1)$, *n* $(22\bar{4}3)$; some double crystals with basal planes inclined at a little over 90° resemble twins, but the basal planes (*cc̄*) are not quite in the zone *cr*, so that this resemblance appears to be deceptive. I am indebted to Mr. L. J. Spencer, M.A., for these crystallographic details.

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[1] It is very usual for the granulitic rocks of Ceylon to be found in this friable, sandy condition, to a considerable depth. This mode of alteration is totally distinct from the formation of laterite, nor does it appear to be due to the kaolinization of the felspars, as these are translucent, and the analysis shows that but little water is present. The change partakes perhaps rather of the nature of a physical disintegration.

The soft, yellow, micaceous band consists of biotite, plagioclase (quite fresh and glassy), greenish-yellow, soft, serpentine-like decomposition-products after pyroxene (?), and minute quantities of garnet and iron-ore. An analysis (No. I) by Mr. W. C. Hancock, B.A., shows that this yellow micaceous band contains a relatively slightly larger proportion of alumina than the corundiferous rock itself.

The corundiferous felspathic rock consists mainly of orthoclase-microperthite, with also plagioclase, biotite, corundum, and small quantities of garnet, green spinel, and zircon. It is not possible to make quite certain of the total absence of quartz; a consideration of the amount of alkali which is, according to the analysis, available would indicate the presence of a small percentage of free quartz; I have not, however, been able to detect any.

The microperthite is in a very fresh condition, the plagioclase still more so. The corundum in the rock has usually a 'court' of felspar free from biotite, separating it from the remainder of the rock, consisting of felspar with scattered biotite.

Professor Sollas, F.R.S., has very kindly made a mineral analysis of the crumbled rock, with the following results:—

Heavy minerals over 3·34 (chiefly corundum)	7·6
Orthoclase, s.gr. 2·56	64·2
Oligoclase (with possibly a little quartz), s.gr. 2·65 ...	23·5
Biotite, s.gr. 2·8–2·92	4·7
	100·0

Mr. Hancock has chemically analysed the same material (No. II); No. III shows the same with water removed and ratios calculated to 100; No. IV, the molecular ratios.

	I.	II.	III.	IV.
SiO_2	47·09	58·44	59·02	·983
Al_2O_3	20·24	20·79	21·00	·210
Fe_2O_3	9·45	·58	·59	
FeO	3·04	3·85	3·89	·065
MgO	2·04	·43	·43	
CaO	3·41	2·24	2·26	·192
Na_2O	1·74	2·85	2·88	
K_2O	4·67	9·83	9·93	
H_2O	9·49	1·36	—	
	101·17	100·37	100·00	

Calculations based on the analysis show that there is a small excess of alumina (above that required for the felspars and biotite) which might be expected to have crystallized as corundum; this excess, however, is smaller than the mineral analysis would lead one to expect.[1]

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[1] The presence of free quartz would raise the amount of available excess alumina, as indicated by the chemical analysis. After careful microscopic examination, however, I feel that there can hardly be any appreciable quantity of free quartz present, if any.

We have, however, in this occurrence a clear case of the occurrence of corundum (and spinel) in a member of the 'Charnockite Series' in Ceylon, in a thin zone interbanded with normal varieties of granulite. It seems more likely that in this case the presence of corundum has resulted from a local variation in the constitution of the consolidating magma than that the magma should have absorbed some rock rich in alumina of which no trace remains here or elsewhere.

The additional alumina can hardly have been obtained from the yellow micaceous band, for in that case the accompanying iron and magnesia would probably have prevented the formation of corundum; this band seems rather to have consolidated from a 'magmatic streak' which, though (like the corundiferous band) rich in alumina, contained too much iron and magnesia to allow of the formation of corundum.

VI.—River Curves round Alluvial Plains.

By T. S. Ellis.

(PAGE-PLATE XIX.)

In the Geological Magazine for October, 1902, Dr. Callaway mentions the explanation of these curves that I gave in a paper printed twenty-one years ago. His quotation should be read with the immediate context—"These [the tributary streams] keep open a channel into which the larger stream falls." This is the essence of my argument.

Professor Phillips and Sir A. Geikie have remarked that an alluvial plain in the course of a river may be regarded as an old lake-bottom, now drained; the lake-like appearance being renewed in times of flood. Let us suppose *ABCD* (Fig. 1) to represent such an area with a river flowing through it in a straight line, and, on one side, a tributary stream, or, to use a shorter and more expressive term, an affluent, coming in at an angle. Such a condition, if it existed, would not continue even in consolidated alluvial soil; it is still less likely to have existed in the soft mud when the area was first drained. A succession of floods would certainly wash away the bank where the affluent, coming through it, had caused a break in its continuity. By this the river-bed opposite the affluent would be expanded beyond its requirements when at low water. At every flood the whole of the bed of the river and the adjoining area of land will be covered with water, the ordinary river channel being effaced. From this water suspended matter falls and forms a deposit, visible after the flood has subsided, but in greater quantity on the banks by the sides of the low-water channel than on the adjoining land. The difference is, in my view, thus explained. The water deep down in the river-bed is subjected to great pressure by that above it, so as to be, relatively to the freely moving current on the surface, stagnant. Any suspended matter in the current that falls into this relatively stagnant water sinks to the bottom, and, in the absence of current there, remains; whereas, in the flood over the land adjoining the river, there is less depth of water, and therefore less liability of the suspended matter to fall below the line of current necessary to keep it in suspension.

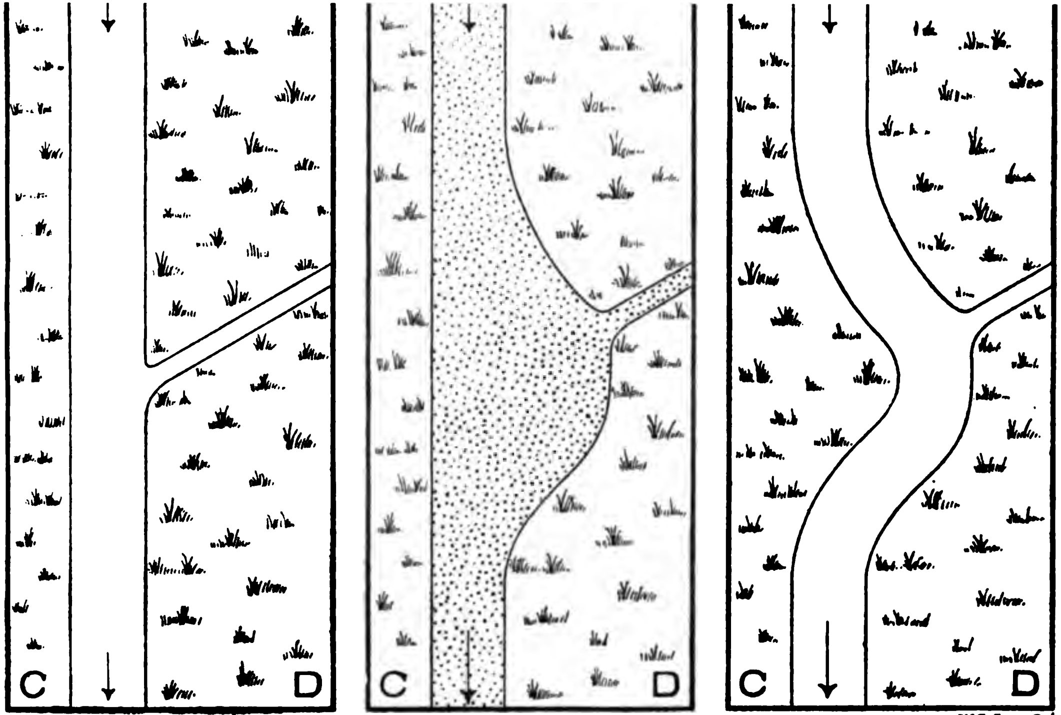

FIG. 1. FIG. 2. FIG. 3.

W. E. James. Del.

Diagram to illustrate Mr. T. S. Ellis's paper on River Curves.

Now we have the floor of the river channel, including the expanded portion, and that of the affluent at its mouth covered with mud, as shown in Fig. 2. When the river sinks to low water the lowest line of channel has to be determined. Clearly, a channel leading from the affluent down-stream is necessary, so that, if one for the river formed on the opposite side, there would be two. But, in fact, the river "falls into and adopts for itself" (to quote words from my paper) the channel kept open by the affluent. Hence the curve as seen in Fig. 3. The deflected river, having been directed against the bank on the affluent side, washes it away at and below the mouth of the affluent. The process being continued the river recedes, generally until the edge of the alluvium has been reached, unless some other diverting influence turns it back, while the undisturbed mud on the opposite side consolidates as it grows until, becoming covered with verdure, it forms part of the meadow on the river margin.

I am reminded that streams often wind freely where no affluents are seen. But it must be remembered that, before the area adjoining the stream became covered with grass, the surface drainage had to run direct into the stream on either side. The series of curves taking in affluents which can be seen in a brook running through the mud of a lake when the dam below has been removed illustrates this, and it is well shown in Professor Huxley's diagram of a catchment basin given in his Physiography.

An affluent is sometimes seen entering a river on the concave side of a broad curve, which must be due to some stronger influence diverting the river from it. This may be the drainage from a hill-slope, not, it may be, enough to make any one stream of considerable size, but, by flowing into the river-bed more rapidly, more effectually keeps open a river channel than the sluggish affluent flowing across the plain can do.

Sir A. Geikie considers "some slight weakness in the river-bank" to be the origin of a river curve. A breach in the continuity of any structure, be it garden wall or river-bank, involves something more than a *slight* weakness. But in the case of a river-bank a channel must be kept open from the breach seawards, which prevents the formation of any support for the bank near the affluent. Thus there is a double cause of weakness. Large sums of money have been spent in putting elements of strength into river-banks. I suggest that it might be better spent in removing elements of weakness, by uniting affluent streams and bringing them, when united, into the river at fixed points, leaving between them a long unbroken front.

Some writers allege that the influence of a side-stream is to drive the river to the opposite side. This, as it seems to me, is contradicted on every map. In my paper I likened an ordinary conjunction of two streams to a capital letter Y, where the faint upper line is in direction continuous with the lower part of the strong line. I did, however, recognize that if a stream were precipitated down the steep side of a valley with sufficient force at right angles to another, the two would produce a resultant of direction. Still, I believe that only in exceptional cases would a river be thus diverted towards the opposite side. The rock material which such an affluent would probably bring down and throw into the river on either side of its own course (forming a 'cone') is much more likely than is the impact of stream against stream to be the real diverting influence.

Dr. Callaway, while recognizing the fact which I had pointed out, that rivers do, as a rule, bend towards their affluents, gives an explanation differing from mine. He argues that the resultant of the two streams will have the effect of carrying the principal part of the detritus brought down by the affluent across the course of the river obliquely down-stream, depositing the suspended matter near the bank on the opposite side. He regards the shoal-bank thus formed as the initial cause of the river curve. I cannot accept this. Large rivers curve which have at the convexity a very small affluent only, just enough to cut the bank down to the river-bed. It is difficult to imagine that the small amount of suspended matter which could have come down such a stream would have had any effect separate from that due to the very much larger amount brought down by the river itself. Moreover, it is at flood-time that most of the suspended matter is brought down. Then the river channel is effaced, a sheet of water covering it and the adjoining land as well as the mouth of the affluent itself. What influence could there be that would determine the dropping of the principal part of the suspended matter brought down by the affluent just within the line of the bank on the opposite side of the river? I can readily imagine that, in the swirling confusion caused by the (literal) con-fusion of the two streams, suspended matter would be likely to fall beneath the current and sink to the bottom at once, and I have seen an affluent after a flood cutting a new passage at its mouth through mud within its own banks. Nor, when the river is not overflowing, can I imagine an affluent that had just enough momentum to carry suspended matter across the stream, but not enough to injure the banks on the opposite side.

In my view, the important question is, not where is sediment deposited—it is deposited everywhere—but in what part of the river-bed is it allowed to remain? As I say, it remains where a channel is not necessary.

Professor Davis, also writing in this Magazine (April, 1903), states that "rivers cannot be habitually straight in their initial stage." Why not? An inquiry into the cause of river curves implies the supposition that, in the absence of a diverting cause, there will be no curve. This is my belief. But if "the bends with which rivers begin are as a rule spontaneously exaggerated in their later development," why not all of them? He adds that "in advanced maturity the river must always be curved." Father Thames is fairly mature, but he has long straight reaches. Theories are generally regarded as good according as they are sufficient to explain phenomena which are manifest. Can the erratic course of the Thames be explained by any "meander system" such as that which Professor Davis expounds, or by any "curve-law" of "volume in relation to velocity" of which we often read? To me it is, throughout, a struggle between the influence of the affluents on the one and those on the other side, each, in turn, prevailing as their size or favourable circumstances may determine. If the great curve at Abingdon be not due to the influence of the river Ock and of other streams lower down, to what is it due? Can it be that the Isle of Dogs was formed "entirely independently of the action of tributaries," while we see that the Thames, in forming it, suddenly strikes southwards and takes in the Ravensbourne; then, as suddenly, striking northwards and taking in the Lea? I have not been able to examine the circumstances of every bend in the Thames, but those that I cannot understand, as seen on the map, are so few as to justify my belief that every one, from Oxford to Woolwich, admits of explanation.

My observations have mostly been made on the Severn, but I have never seen any reason to doubt the general application of the laws first suggested to me by these facts:—Above Gloucester is the "Long Reach," no affluents and a straight river; opposite the town, affluents on both sides and multiple channels, now only two enclosing the island of Alney; below the town, affluents on either side and a river with large or small curves according to the position of the affluents; in the estuary, affluents on both sides, and an ever-continuing struggle as to the extent to which either will prevail in having the principal channel on one or on the other side.

NOTICES OF MEMOIRS, ETC.

I.—On Reptilian Remains from the Trias of Elgin. By G. A. Boulenger, F.R.S.[1]

DESCRIPTIONS are given of various reptilian remains obtained by Mr. William Taylor, J.P., of Lhanbryde, in the Triassic sandstone quarries at Lossiemouth, near Elgin. Thanks to the kind permission of Dr. A. S. Woodward, the fossils were further developed in the Geological Department of the British Museum by Mr. Hall.

The remains described belong to three different reptiles.

1. *Hyperodapedon Gordoni*, Huxley.

A skull is contained in a block of sandstone, split horizontally in the plane of the palate, which is for the first time clearly exposed. The structure of the palate is seen to have been very different from what Huxley had surmised, and shows a much nearer approximation to that of *Sphenodon*. The choanæ were elongate, oval, and situated between the palatines and the vomers at some distance behind the premaxillaries. Doubts have been thrown on Huxley's interpretation of the outer toothed bone of the skull, and it is important to settle the question of its identification. The new material has convinced the author that the teeth in the upper jaw are borne by both the maxillary and the palatine as stated by Huxley. The fossil shows well the elongate rhomboidal vacuity between the pterygoid, ending at the point where they converge before diverging again towards the quadrate, to the massive anterior branch of which they are suturally united.

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[1] Abstract of a paper (published by permission) read before the Royal Society of London, June 11th, 1903 (Proc. Roy. Soc., vol. lxxii, pp. 55–58).

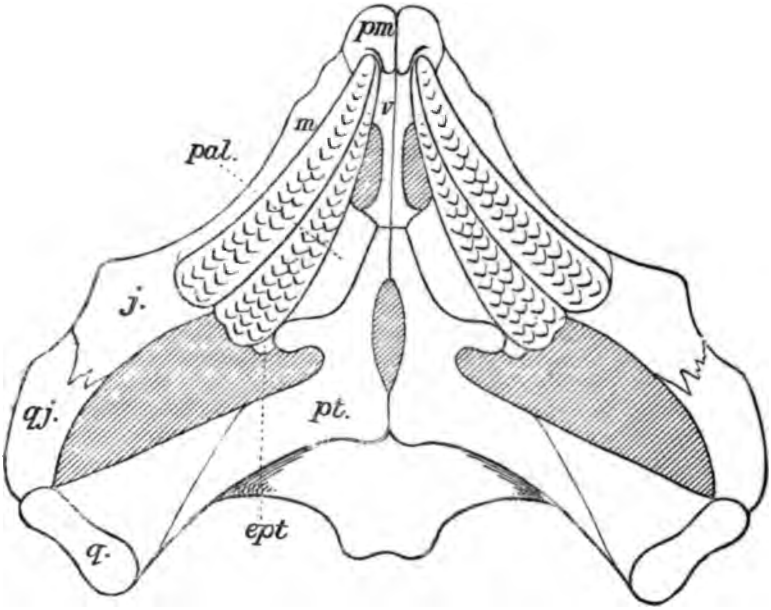


Fig. 1.—Palatal view of skull of *Hyperodapedon Gordoni*, Huxley.
ept. ectopterygoid; *j.* jugal; *m.* maxilla; *pal.* palatine; *pm.* premaxilla; *pt.* pterygoid; *q.* quadrate; *qj.* quadrato-jugal; *v.* vomer.

As may be seen from the annexed restoration, the palate of *Hyperodapedon* bears great resemblance, in its general structure, to that of the living *Sphenodon*, the principal differences, apart from the dentition, residing in the smaller bony roof of the mouth and the narrower vomers.

2. *Stenometopon Taylori*, gen. et sp. nov.

This name is proposed for a considerable portion of a skull of a Rhynchocephalian, closely related to *Hyperodapedon*, and belonging to the same family, Rhynchosauridæ. Its length is 177 mm. and its greatest width 160. One of the most striking features of *Hyperodapedon* as compared with its New Zealand ally, *Sphenodon*, is its much broader and more massive skull. The skull of the new Rhynchocephalian, although agreeing in its general structure with that of *Hyperodapedon*, is not broader and hardly more massive than that of *Sphenodon*, from which it differs, however, very much in shape. The rostrum has quite a different direction from either of these skulls; the tusk-like premaxillaries, instead of being bent downwards into recurved processes, are directed forwards in a gradual slope from the frontal region to their extremities, which project beyond the turned-up extremities of the mandibular rami. This is practically the reverse of the condition in *Hyperodapedon*, where the strongly curved premaxillary 'tusks' are received between the outwardly directed rostral processes of the mandible. Nasal bones are absent.

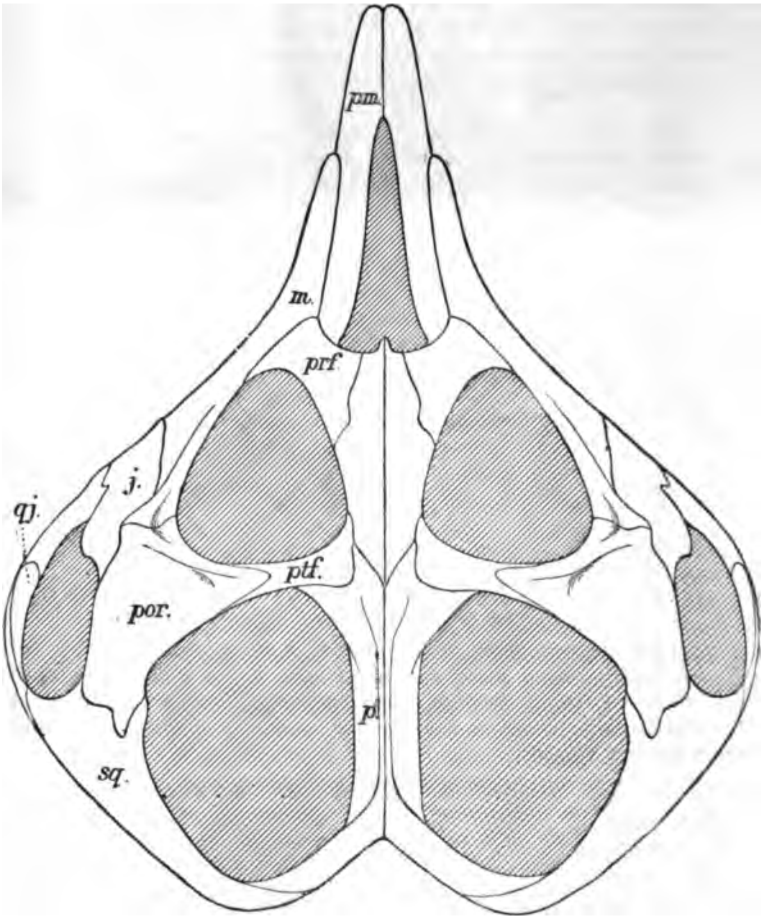


FIG. 2.—Dorsal aspect of skull of *Stenometopon Taylori*, gen. et sp. nov. *j.* jugal; *m.* maxilla; *p.* parietal; *pm.* premaxilla; *por.* post-orbital; *prf.* prefrontal; *pm.* premaxilla; *ptf.* post-frontal; *qj.* quadrato-jugal; *sq.* squamosal.

As in *Hyperodapedon*, the nasal aperture is single, but, in accordance with the shape of the premaxillaries, it is more elongate, its length being to its width as 2⅓ : 1; its posterior border extends to the level of the orbits, which are entirely directed upwards. The inter-orbital region is narrow, especially behind. The supra-temporal fossæ are very large, separated from the orbits by the narrow post-orbital arch and from each other by the sharp median crest of the parietals. The latero-temporal fossa is kidney-shaped, and proportionately larger than in *Hyperodapedon*, but smaller than the supra-temporal fossa. The maxillary bone is deep and nearly vertical, with an oblique ridge extending downward and backward to the jugal; the maxillary teeth, so far as they are preserved, appear very similar to those of *Hyperodapedon*, and form a single series in front and two behind. The palate is imperfectly preserved, but what is left of it agrees in essential points with *Hyperodapedon*; the palatine teeth are disposed in three series behind.

3. *Ornithosuchus Woodwardi*, E. T. Newton.

The specimen on which this species was founded by Mr. Newton in 1894 indicated a reptile about 2⅔ feet long. Specimens more than twice as large are now described, and afford much information on points which remained obscure. Clavicles were present, large and widely expanded at their inner extremity, where they overlapped the inter-clavicle. A plastron, or system of abdominal ribs, was also present, resembling very closely that of *Sphenodon*, each segment being formed of a median angulate piece, to which a lateral limb is attached, the segments, however, being much more numerous and closer together than in the New Zealand reptile.

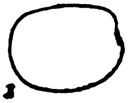
The presence of clavicles and of a plastron show that *Ornithosuchus* cannot be included among the Dinosaurs, as originally suggested, but must be placed in the order Thecodontia of Owen, which contains *Belodon* and *Aëtosaurus*. The Thecodontia should be kept distinct from the Crocodilia or Emydosauria; they agree with the latter, the Dinosauria, and the Pelycosauria, to which they are very closely related, and differ from the Rhynchocephalia, in the truly thecodont dentition; they agree with the Rhynchocephalia and Pelycosauria, and differ from the Emydosauria and Dinosauria, in the presence of clavicles, whilst they show close resemblance to the Rhynchocephalia proper in the structure of the plastron. The presence of clavicles and the condition of the pelvis, in which the pubis enters the acetabulum, together with other characters showing greater generalisation, afford ample justification for the separation of the Thecodontia or Parasuchia, as a group of ordinal rank, from the Emydosauria. The author also expresses the opinion that precision in the definition of the higher group of reptiles would gain much by the order Dinosauria being restricted to the carnivorous, truly thecodont forms, the others deserving to form an equivalent order under the name of Orthopoda, Cope (Predentata, Marsh; Ornithischia, Seeley).

II.—DESCRIPTION OF A NEW SPECIES OF *MATHERIA* (*M. BREVIS*), FROM THE TRENTON LIMESTONE AT OTTAWA.[1] By Dr. J. F. WHITEAVES, F.G.S.

THE genus *Matheria* was described by E. Billings in 1858, in the third volume of the Canadian Naturalist and Geologist. It was based upon a single species, the *M. tener* of Billings, a small lamellibranchiate or pelecypodous bivalve, from the Trenton Limestone at Lake St. John, P.Q. *Matheria* appears to be most nearly related to *Cyrtodonta* and *Vanuxemia*, and is now included in the family Cyrtodontidæ, Ulrich, of the order Prionodesmacea, Dall. The types of *M. tener*, which were collected by Mr. J. Richardson and Dr. R. Bell in 1857 at Blue Point, on Lake St. John, are still in the Museum of the Geological Survey.

A second species of this genus, from the Trenton shales of Minnesota, was described by Mr. Ulrich in 1892, under the name *M. rugosa*, in the Nineteenth Annual Report of the Geological and Natural History Survey of Minnesota. And, in his Report on the Lower Silurian Lamellibranchiata of Minnesota, published in 1897, in vol. iii, pt. 2, of the Final Report on the Geology of Minnesota, Mr. Ulrich expresses the opinion that the *Modiolopsis recta* of Hall, from the Niagara Limestone of Wisconsin and Illinois, is also a *Matheria*.

In the Museum of the Geological Survey there are a few specimens of a fourth and previously undescribed as well as unfigured species of this genus, from the Trenton Limestone of Ottawa, collected many years ago by E. Billings, and labelled by him with the manuscript name *Matheria brevis*. This species may now be defined and characterized as follows.



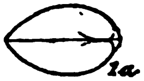


FIG. 1.—*Matheria brevis*. Side view of the most perfect specimen collected, in outline, and showing the marginal contour of the right valve.

FIG. 1*a*.—The same specimen, as seen from above, to show the amount of convexity of the closed valves.

Both of these figures are of the natural size.

Shell small, inflated, and regularly convex, but not quite as wide as high, suboval or oblong subquadrate, about one-third longer than high, and very inequilateral. Anterior side very short, narrow, and consisting of a small rounded lobe below the beaks on each side; posterior side longer, and a little wider in the direction of its height;

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[1] Reprinted from the "Ottawa Naturalist," Journal of the Ottawa Naturalists' Club, vol. xvii (1903), pp. 33–34, May Number, Ottawa, Canada.

posterior end vertically subtruncate at its mid-height, rounding abruptly into the cardinal margin above and into the ventral margin below. Ventral margin gently convex, but curving upward more abruptly and rapidly at the posterior than at the anterior end; superior border almost straight and nearly horizontal; umbones depressed, anterior, very nearly but not quite terminal; beaks incurved.

Surface-markings not at all well preserved in either of the specimens collected, but apparently consisting of fine concentric lines of growth. Hinge dentition and muscular impressions unknown.

Approximate dimensions of the specimen figured: maximum length, 15 mm.; greatest height, 11 mm.; maximum width, or thickness through the closed valves, nearly 9 mm.

Trenton Limestone, Ottawa, E. Billings: four nearly perfect but badly preserved specimens.

M. brevis can be distinguished at a glance from *M. tener*, *M. rugosa*, and *M. recta*, by its comparatively short, tumid, and regular convex valves.

III.—The use of Carboniferous Plants as Zonal Indices. By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

THE student of Carboniferous plants has long ago realized that the kind of evidence which is drawn successfully from the distribution of marine invertebrata is inapplicable and inaccurate in the case of fossil plants. For instance, as is well known, the Jurassic rocks are divided into a number of zones on the occurrence of a species of Ammonite, confined or almost wholly confined to a particular zone. Apparently in regard to the Carboniferous mollusca, the same principle is being applied. Efforts are being made[2] to obtain one or two definite but common mollusca which occur in one subdivision of the Coal-measures, but which are absent or almost entirely absent from others, and to use such species as zonal indices. How far this will prove possible in the case of a fauna which has for the most part a wide vertical range, and which is not truly marine but largely littoral, estuarine, or even fresh-water, remains to be seen. The discovery of restricted species of plants is not, however, the primary object of the palæobotanist. Some geologists, realizing that fossil plants do not commonly afford this type of evidence, have rather hastily concluded that such remains are therefore useless as zonal indices. I hope, however, to show that this is not the case. It is true that in British rocks a number of plants are, so far as our knowledge extends, confined to one of the minor divisions of the Carboniferous, such as the Middle Coal-measures. This is the case with *Zeilleria delicatula* (Sternb.) and

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[1] Abstracted from a paper read before the North of England Institute of Mining and Mechanical Engineers in June, 1903, and published in the Transactions of the Institute for the current year.

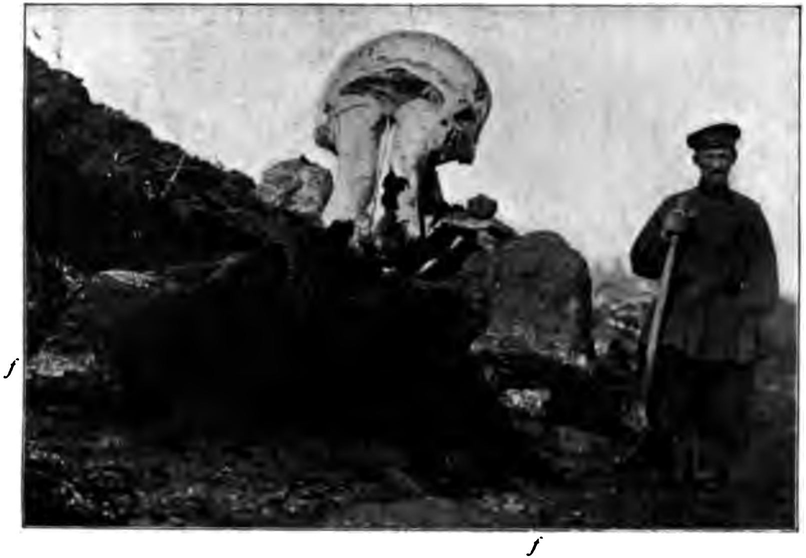
[2] "Life-Zones in the British Carboniferous Rocks: Report of the Committee": Report British Association, Bradford, 1900, pp. 340–342.

Sigillaria ovata Sauveur, plants which have recently been found in the Cumberland Coalfield. The evidence of such restricted species is not, however, the foundation of any method of zoning by means of fossil plants, although it is often important as affording confirmatory support to conclusions gained on entirely different grounds.

In order to establish the position of any bed in the Coal-measures, it is necessary to collect and to study a number of different species from it or from the associated rocks; in other words, we must know not one or two species, but a flora. The number of species need not, however, be very large. Usually twenty species or even less will suffice if they belong to diversified types of plants, but the larger the number the better. It is the relative abundance of certain types of plants at any one horizon, and the absence of other types, rather than the occurrence of particular species, which gives the solution to the problem of the horizon of the bed in question. By taking into account the aggregate or assemblage of plant types, the common occurrence of certain classes, genera, subgenera, or species, and the absence or rare occurrence of others, species which have a wide range in time in Carboniferous rocks can be made to yield evidence. Such species, despite their range, are found to be much more abundant in some of the subdivisions of the Carboniferous than in others.

Thus the common occurrence of *Lepidodendron aculeatum*, Sternb. in coal-bearing strata in itself points to such beds being of Middle or Lower Coal-measure age, rather than Upper, as this species has been found to occur most abundantly on these horizons, and less abundantly in the Upper Coal-measures. From a number of separate small conclusions of this nature a general conclusion can be arrived at, for which support can often be found from other lines of evidence, such as the occurrence of restricted species. Again, an abundance of such types of plants as *Calamites* and *Sigillaria*, in association with *Sphenopteris*, and an absence of particular types of *Pecopteris*, *Alethopteris*, and *Cordaites*, will help to distinguish a Middle from an Upper Coal-measure flora.

Occasionally small points of disagreement with a general result are found. *Alethopteris Serli*, Brongt., a characteristic Upper Coal-measure fern-like plant, is sometimes found in the Middle Coal-measures, as for instance in Cumberland. The disagreement of a single character does not, however, invalidate the conclusion drawn from an aggregate of characters. Such disagreements occur among recent plants which are classified on very similar principles to those applied here. In the recent family Scrophulariaceæ, the presence of five stamens in the flower is a single character contributing towards an aggregate of characters which distinguishes this family or natural order from others. But many, perhaps the majority of genera belonging to this family possess only four or two stamens, whereas their other characters, as a whole, clearly point to close affinity with other members of the Scrophulariaceæ possessing five stamens. It need hardly be pointed out that if all



Photograph of the newly discovered Mammoth (*Elephas primigenius*), taken *in situ*.

Exposed by a landslip on the banks of the Beresowka, a tributary of the Kolyma, in the province of Jakutsk.

The skull was quite bare (the soft parts having been destroyed by foxes, etc.), but the body and the feet and limbs (*f*, *f*) were found still covered with the integument.

The skeleton and the skin are now both preserved and exhibited in the St. Petersburg Academy.

the plants which possess five stamens were thrown into a group founded on this one character, that group would not be a natural one, since it would include a large number of genera in no way related to one another.

IV.—A METHOD FOR THE INVESTIGATION OF FOSSILS BY SERIAL SECTIONS. By W. J. SOLLAS, D.Sc., LL.D., F.R.S., Professor of Geology and Palæontology in the University of Oxford.[1]

MECHANICAL difficulties preclude the study of fossils by serial thin slices, but serial polished surfaces may be obtained at any desired degree of proximity, and these, when the fossil and its matrix offer sufficient optical contrast, serve most of the purposes of thin slices. They may be photographed under the microscope, so as to furnish a trustworthy and permanent record. The sections may be used to obtain reconstructions of the fossil in wax. Several fossils have been successfully studied in this way, such as *Palæospondylus Gunni, Ophiura Egertoni, Lapworthura Miltoni, Monograptus priodon*, and *Palæodiscus ferox*. The sections are obtained at regular intervals, usually of 0·025 mm., by means of an apparatus designed for the purpose by the Rev. Jervis Smith, M.A., Reader of Mechanics in the University.

REVIEWS.

I.—THE MAMMOTH.

(PLATE XVIII.)

1. BERICHTE DES LEITERS DER VON DER KAISERLICHEN AKADEMIE DER WISSENSCHAFTEN ZUR AUSGRABUNG EINES MAMMUTH-CADAVERS AN DIE KOLYMA-BERESOWKA AUSGESANDTEN EXPEDITION. By OTTO HERZ. pp. 38, pls. x. Imperial Academy of Sciences, St. Petersburg, 1902.
2. BODENEIS VOM FLUSS BERESOWKA (NORD-OST SIBIRIENS). By I. P. TOLMATSCHOW. Verhandl. k. russ. mineral. Ges., vol. xl, pp. 415–451, pls. v–viii (1903).
3. OSTEOLOGICAL AND ODONTOGRAPHICAL COMPARISON OF THE MAMMOTH (*ELEPHAS PRIMIGENIUS*, BLUM.) WITH THE LIVING ELEPHANTS (*E. INDICUS*, LINN., AND *E. AFRICANUS*, BLUM.) [in Russian]. By W. SALENSKY. pp. 124, pls. xxv. Imperial Academy of Sciences, St. Petersburg, 1903.

WHEN it was announced two years ago that the St. Petersburg Academy of Sciences had despatched an expedition to Siberia to obtain a newly discovered Mammoth, great interest was aroused. Previous attempts to recover a complete carcase had always ended in failure, owing to the difficulty of reaching any reported specimen in good time. On this occasion, however, it was hoped that the facilities afforded by the new trans-Siberian railway and the modern appliances of science would result in success, and at any rate give opportunities for exact observations on a carcase in the tundra, even if the decaying mass could not be transported to a museum. The official report of the expedition published last year by its leader, Dr. Herz, showed that the most sanguine expectations of the Academy had been fulfilled. The great carcase was successfully unearthed and photographed at various stages of the work; the remains were packed with special care and speedily transported to St. Petersburg; and on reaching the Zoological Museum the material was found to have arrived in so satisfactory a state that it was not only good enough for scientific study but could also be mounted for public exhibition. The mounting has just been completed under the direction of Dr. Salensky, and the specimen is now one of the most remarkable objects of natural history in Europe. The animal is a young male of rather small size. The skeleton has been removed from the skin and surrounding soft parts, and fixed up separately on a wooden pedestal. The skin has actually been softened, prepared, and stuffed by a taxidermist, just like a modern skin; and some of its deficiencies have been hidden by mounting it in the attitude of death surrounded by the morass in which it made its final struggle. The skin of the head and ears is restored, copied from the specimen discovered and brought back by Adams a century ago. The proboscis, so far as shown, is also artificial. Some patches of wool and hair from other specimens have been added to cover bare places. Otherwise it is a genuine specimen.

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[1] Abstract of a paper read before the Royal Society of London, June 11th, 1903.

Like most other carcases which have been reported, this new Mammoth was found nearly in the latitude of the Arctic Circle. It was disclosed by a landslip on the banks of the Beresowka, a tributary of the Kolyma, in the province of Jakutsk. The head was naturally exposed, and its soft parts were thus destroyed and eaten by the foxes and other carnivorous animals. The rest of the specimen, thanks to the intervention of the Governor of Jakutsk, was kept covered and intact until the arrival of the Academy's expedition. After surmounting some preliminary difficulties, Dr. Herz began to excavate backwards from the head. He first uncovered the two fore limbs, which were found in the remarkable sprawling attitude shown in his photograph (here reproduced in Pl. XVIII). Both were bent at the wrist, and clearly showed that the animal had fallen into a hole and was trying to escape. The hind limbs were then found bent completely forward beneath the body. The tongue, which was beautifully preserved, was observed to be hanging out of the mouth; and the cavity of the chest was filled with clotted blood. It may therefore be concluded that the animal was entrapped, and died from the bursting of a blood-vessel near the heart in its efforts to extricate itself.

A still more interesting fact was noted by Dr. Herz, namely, that the mouth was filled with grass which had been cropped but not chewed and swallowed. Death appears thus to have been quite sudden. The stomach was also well filled with grass, and contained no other kind of food. Dr. Herz therefore suggests that the

Mammoth may have been quietly grazing on grass-covered land which had accumulated above a glacier, when it fell into a hidden crevasse. It was found surrounded partly by ice, partly by frozen earth and gravel; and, according to the researches of Dr. Tolmatschow, the ice had undoubtedly the character of a glacier formed from snow, not formed directly from a lake or river.

Dr. Herz is not a geologist, and does not pretend to express an authoritative opinion on the geological aspect of his discoveries. A trained geologist, however, M. Ssewastianow, examined the region of the Beresowka last summer, and we may shortly expect more important observations in his forthcoming Report. Meantime, it is clear that the only mammoth-carcase of which we have adequate knowledge represents an animal which fed on grass and met its death as the result of a local accident. It did not depend for sustenance on scrub or forest-growth, as the Mammoth is sometimes assumed to have done. It cannot be regarded as lending any support to the theory of the destruction of these great quadrupeds by a flood or any unusual cataclysm.

Regarded from the zoological point of view, the new specimen is of supreme importance, and Dr. Salensky is preparing a series of memoirs upon it. The first of these, dealing with the skeleton and teeth, has just appeared, and is illustrated with numerous figures. Our only regret is that his work is not generally accessible on account of it being written solely in the Russian language.

A. S. W.

CORALS AND CORAL REEFS IN THE PACIFIC.

II.—Memoirs of the Museum of Comparative Zoology at Harvard College, vol. xxviii.

Reports on the Scientific Results of the Expedition to the Tropical Pacific, in charge of Alexander Agassiz, by the United States Fish Commission Steamer "Albatross," from August, 1899, to March, 1900; Commander Jefferson F. Moser, U.S.N., commanding. IV. The Coral Reefs of the Tropical Pacific. By ALEXANDER AGASSIZ. 4to: pp. xxxiii, 410; 236 plates. February, 1903. One volume text, three volumes plates.

IN May, 1899, Alexander Agassiz published in the Bulletin of the Museum of Comparative Zoology, Harvard College, vol. xxxiii, his account of "The Islands and Coral Reefs of Fiji," with 120 plates and 168 pages of text 8vo (see GEOL. MAG., pp. 407–421). If the earlier work formed a most valuable contribution to the literature of coral reefs, this later and larger memoir is, like the reefs themselves, 'monumental.'

Professor Agassiz reports that, "While in charge of the Expedition of the United States Fish Commission Steamer 'Albatross' during the Winter of 1899–1900 we visited the coral reef districts of the Tropical Pacific, with the exception of the Sandwich, the Samoan Islands, and the Galapagos.

"The Hawaiian Islands I had explored on former occasions, and had also obtained a bird's-eye view of the reefs of Samoa on my way to examine the Great Barrier Reef of Australia.

"It has thus been my good fortune to observe the structure of the great majority of the coral reefs, atolls, and coral islands of the tropical Pacific, and to have the benefit of the excellent charts published since the days of Darwin and Dana.

"One cannot over-estimate the great advantages to be derived from recent surveys in studying groups of coral islands like the Fiji or the Society Islands. The charts and 'Sailing Directions' contain an amount of information which no one individual could hope to bring together, and their publication has made it possible for an observer to cover an immense area and obtain within a reasonable time an insight into the structure of the coral reefs of an oceanic realm like the Pacific."

Professor Alexander Agassiz's observations and investigations on coral reefs date back to 1877 (over a quarter of a century), and have now covered the principal coral reefs and islands of the Pacific, the West Indies, and the Indian Ocean.

"The explorations" (says Agassiz) "were not continued for the sake of proving Darwin to be wrong, as seems to be the impression of some of my critics. Year after year the subject of coral reefs became more engrossing, and it was studied for its own sake. I had no theory of my own as a guiding star, nor did I attempt to uphold any one of the theories on coral reefs advanced since the publication of Darwin's 'Structure and Distribution of Coral Reefs.'"

The author gives a summary of the various and very numerous sources of information on coral reefs which he has been able to consult, including the many missionaries whose journals contain much information regarding coral reefs and islands in which they had spent years; also to the reports of voyages of English, French, and Russian navigators; he specially cites the voyage of the "Blossom" under Beechy, of the "Beagle" and the United States Exploring Expedition under Wilkes, as memorable for their reports on coral reefs by Darwin and by Dana, and on the geology of the islands of the Pacific. Agassiz also quotes the British Admiralty Surveys, and those of the French Hydrographic Bureau, as well as various minor expeditions of the United States Government.

Sir John Murray's Memoir on the "Structure and Origin of Coral Reefs" (Proc. R. S. Edinburgh, 1880) is referred to, in which Darwin's theory of the formation of barrier-reefs and atolls was discussed.

Semper's investigations in the Pelew Archipelago were carried on as far back as 1861, when he spent nearly ten months in the Pelews, and called attention (Leipzig, 1880) to the fact that all kinds of reefs (atolls, barrier, and fringing reefs) are found in the Pelews, within a comparatively short distance, in a region considered by Darwin as one of subsidence, and that at the southern extremity of the group an elevated coralliferous limestone island (Ngaur) rose to a height of over 300 feet, containing, according to Wichman, fossils of late Tertiary age. Semper lays great stress on the effects of currents between the land-rim and the barrier-reef in widening barrier-reef lagoons; and Agassiz has described reef-platform lagoons which illustrate this well.

Semper also suggests that marine animals may build up a foundation for the growth of reef-corals from far greater depths than those at which corals can thrive.

This writer also first called attention to the effect of solution in removing material from an atoll, but it is to Sir John Murray (1889–90, Proc. Roy. Soc. Edinb., xvii, p. 79) that we owe those careful experiments to determine the amount of lime removed by solution, and the suggestion of its importance as a factor in the formation of lagoons. Semper even considers the effect of solution in removing lime from the lagoon of an atoll as balancing the constructive agencies proved by the growth of corals in it.

Agassiz points out that Professor Dana was the principal supporter of Darwin's theory of the formation of coral reefs, and that the areas which these eminent naturalists and explorers covered in their investigations seemed to include all that was essential to satisfy the demands of Darwin's theory.

The author gives a summary of each important group of coral islands visited, with their chief characteristics, describing in detail the structure of the Sandwich and Samoan Islands; the Paumotu Archipelago; the Ellice, Marshall, and Gilbert Islands; the Gloucester Islands, and Marquesas; the Cook Archipelago; the Tonga Archipelago; the Haapai group to the north of Tongatábu.

"Groups like the Ellice, Gilbert, and Marshall Islands give us the means of studying the many modes of formation of the land-rims in a most satisfactory manner. Nowhere have we been able to follow as clearly the results of the various agencies at work in shaping the endless variation produced in the islands and islets of the land-rims of the different atolls of these groups; changes due either to slight elevation or to the incessant handling and rehandling of the older material in place, or of the fresh material added from the disintegration of the sea or lagoon faces of the land-rim, or of the corals on the outer and inner slopes. It has been most interesting to trace the ever-changing conditions which have produced so many variations in the appearance and structure of the islands, islets, and of the land-rims of the different groups.

"In the Fiji, as in the Society Islands, the wider fringing reef-flats often pass gradually into barrier-reefs with a narrow lagoon between the outer edge of the reef platform and the shore line. The rotten condition of the inner part of a wide fringing reef is most favourable to its removal by solution or mechanically, and leads to the formation of narrow lagoons, which may, as is the case in Tahiti, become wide and deep barrier-reef lagoons. The small number of islands and islets of the outer barrier-reef in Fiji atolls contrast strongly with the well-wooded islands and islets on the encircling belt of the Society Islands.

"The disintegration of the masses of corals growing upon a reef is due to the boring Echini, Mollusks, Annelids, Crustacea, and sponges, which infect the large masses; as these become weakened, they are torn off by the waves and rapidly reduced to shingle. The smaller fragments are then still further disintegrated by boring sponges and Algæ, and by attrition on the wide reef platforms, both of the sea face and lagoon side, reduced first to coarser, then to fine sand and impalpable silt, which may be carried off in suspension. In addition to the mechanical destruction constantly going on, chemical action takes place, and water carries off in solution large quantities of lime from the sea face, where we can trace the extent of its action from the undercut faces of cliffs, of masses of corals, and the rotten condition of smaller fragments of corals.

"The same action takes place in the lagoon even to a greater extent; in every direction we can trace the effect of solution on the beach rock beaches, the conglomerate or breccia ledges, the patches of corals, the samples of the bottom, the slopes of the shoals or ledges within the lagoon, all showing that solution is a prominent factor in removing carbonate of lime from the interior of a lagoon." (p. xxiv.)

We may approximately classify the atolls, elevated islands, and volcanic islands where reefs are found, into the following categories:

Large volcanic islands with barrier and fringing reefs, like Tahiti, Viti and Vanua Levu, and the larger Samoan Islands; in these the land mass occupies a large area as compared with that of the reefs. Viti Levu and Vanua Levu, as well as Solomon, New Hebrides, and Oahu in the Sandwich Islands, are partly flanked by elevated coralliferous limestone.

Next may come smaller volcanic islands with barrier and fringing reefs, like the Pelew Islands, Yap, Truk, Ponapi, Kusaie; the smaller New Hebrides and Fiji Islands, like Nairai, Makongai, Mbengha; the volcanic islands of the Cook group, as Aitutaka, Raratonga; the Horne Islands, Rotumah, the Marquesas, and such islands as Maupiti, Bora Bora, Raiatea, Huaheine, Eimes, in which the area of encircling reefs is as large as, if not larger than, the enclosed volcanic mass.

Volcanoes like Totoya and Thombia in Fiji show the possibility of the formation of an atoll-like island by the growth of corals on the submerged or denuded rim of an extinct volcano. In Totoya the extension of the volcanic reef-rim forms a barrier-reef surrounding the island and enclosing a barrier-reef lagoon, with ship-passes into it.

Niuafóu and Tofua in Tonga are both islands with extinct craters filled with brackish water. Were the rim cut down to below the level of the sea, they would become reef-flats enclosing a deep lagoon, as is the case with a part of the rim of Thombia and Totoya.

Elevated coralliferous limestone islands, probably of Tertiary age, with limited areas of narrow reef-flat platforms, like Makatea, Niue, Nauru, Paanopa, Naiau, Wangava, with ill-defined sinks or basins occupying part of the summit.

Elevated coralliferous limestone islands, like Mango, Kambara, Tuvuthá, in which the sink is better defined, and where a volcanic outburst has broken through the rim or central part of the sink or both.

Elevated islands of coralliferous limestone, like Fulanga, Yangasá, Ongea, where the sea has eaten through the limestone rim towards the inner sink, cutting the rim into islands, and has formed a sound or lagoon dotted over with limestone outliers, forming undercut and weathered islands and islets. The encircling land-rim may disappear or be reduced to a few heads, as in Argo, Ongea, or Yangasá.

Elevated coralliferous limestone islands, cut down nearly to the level of the sea by atmospheric agencies, like Niau in the Paumotus, with a shallow sink (lagoon) connecting with the sea only through the porous mass of the land-rim, or Rangiroa, and the majority of the islands in the Paumotus, and some of the Gilbert Islands (Apamama Tapeteuea), with a lagoon enclosed by a land-rim composed of disconnected islands and islets forming passes and gaps communicating with the sea; islands all noted for the great development of buttresses of modern reef rock and of Tertiary age on the reef platforms, the remnants of a higher land mass now denuded to the level of the sea. Similar outliers in the lagoon form shoals, islands, and islets.

Extensive elevated limestone masses, like those of the Tonga Archipelago, with volcanic outbursts of limited extent that have pushed through the limestone masses.

Atolls with disconnected limestone and volcanic islands, the remnants of islands partly volcanic and partly limestone, like Guam and Eua, only on a smaller scale. In these the volcanic outbursts as well as the limestone masses have been denuded and eroded, and formed the groups of Vanua Mbalavu, Lakemba, Naitamba, Mothe, and the like.

Low atolls, like those of the Ellice, Marshall, and the Gilbert Islands in part, where the land-rim is reduced to a minimum and best developed on the weather side, and where the material composing it is subject to constant transport, the material being derived from the corals growing on the sea slope of the reef-flat platforms and from the disintegration of the slightly elevated modern reef rock conglomerate or breccia. Atolls all characterized by the great changes taking place in the extent of the islands of the land-rim, owing to the formation of sand bars, shoals, flats, bays, the closing of gaps, the filling of lagoons by sand blown in from the sea face, the throwing up of extensive dams on the lagoon flats to form secondary lagoons, the existence of reef platform lagoons; the islands on the land-rims of these atolls being flanked with coral sand, shingle, or boulder beaches on the sea face, with sand beaches or beach rock flats on the lagoon faces. The islets, shoals, and islands in the lagoons are either patches of elevated modern reef rock or knolls of growing corals, many of them with deep passes, usually most numerous on the lee side. The corals growing on the sea slope of the reef platforms are often overwhelmed by sand dunes blown over the land-rim from the lagoon flats.

Atolls, like Tarawa, Tapeteuea, and Nonuti in the Gilbert group, and Makemo, Fakarava, and others in the Paumotus, with a well-developed land-rim on the weather-face flanked on the lee by submerged reef-flats.

Finally, such islands and islets as Tikeï, Nukutavake, and a number of small islands with central sinks and depressions formed by the beaches thrown up on the outer edge of the flat or summit of the island, leaving an open central space enclosed by the beach-dams. Similar islands occur in the Gilbert group, as Arorai and Tamana; Mejit, Lib, and Jemo in the Marshall and Nurakita, and Nanomana in the Ellice groups." (p. xxviii.)

The Ellice group is of especial interest to geologists in this country, as it was in the island atoll of Funafuti, one of this group, that the Royal Society decided to make trial borings to ascertain its structure, and Professor Sollas[1] commenced work on 21st May, 1896, a task which was continued by the Government of New South Wales,[2] under the direction of Professor Edgeworth David, F.R.S. After various trial borings, a boring 947 feet, or 147 feet below the base of the steepest cliff, was accomplished, the material passed through being coral limestone, containing numerous well-preserved corals.

Professor Agassiz has evidently felt the importance of this investigation, for he has devoted seventeen pages to a description of this atoll, and three plates and three charts to its illustration.

"All the soundings known indicate that coral reefs rise independently upon summits formed by Tertiary limestones or volcanic rocks, summits which have been formed either by elevation or submarine denudation, or upon summits of accretion forming submarine banks.

"The nature of the underlying base is naturally an important factor in determining the pitch of the sea slope; we may assume that the steep slopes of the upper part of reefs is due to the sloughing off of the limestone cliffs down to thirty or forty fathoms, much as they are sloughed off from the faces of elevated islands above high-water mark. If composed of volcanic ash or harder volcanic materials the slope in one case will be very slight, spreading rapidly laterally under the influence of the waves; in the other, the slope of volcanic material will not differ materially under water from that above high-water mark. When the slope is a talus of reef material it may lie at a steep angle or may follow closely the slope of the underlying base below the depth at which corals or Nullipores grow." (p. xxx.)

It had been Professor Agassiz' intention, he tells us, to investigate the marine fauna of each of the great oceanic groups of islands and trace the passage of the littoral into the abyssal fauna, and to obtain the material needed for a comparison of isolated oceanic faunæ to one another. Unfortunately he was unable to carry out this part of the programme.

It is refreshing to find the author expressing the opinion, that in spite of all that has been accomplished during the last 25 years towards settling the debateable points of the theory of coral reefs, *much remains to be done.*

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[1] Proc. Roy. Soc., 1897, pp. 502–515.

[2] *Natural Science*, 1899, pp. 17–37; and Proc. Roy. Soc., December, 1897, pp. 200–202.

Most important is an extensive system of boring[1] at well-selected points, to include barrier and fringing reefs and atolls in volcanic and other districts, as well as elevated coralliferous limestone islands, or islands partly limestone and partly volcanic; to be supplemented by lines of soundings and dredgings taken from low-water mark to the depths at which oceanic slopes are met.

The data thus obtained would give us the pitch of the slope of the strata underlying a barrier and a fringing reef, and of its continuation beyond the outer edge of the barrier reef.

For an atoll the bore would indicate the width of the talus, the original dimensions of the summits upon which the recent reef rock material was deposited, and the extent of lateral growth, both seaward and lagoonward. This would give a degree of precision now wanting in Professor Agassiz's recorded observations.

"On whatever side" (says Professor Sollas) "judgement may ultimately be given in the question, the thanks of the scientific world must undoubtedly be conceded to Sir John Murray for having disturbed a decided opinion from its slumber, for having awakened a fresh interest in Darwin's theory, and in thus leading to renewed investigation, which is both adding to our knowledge and suggesting fresh inquiry." (*Natural Science,* vol. xiv, p. 36.)

Of the 236 plates accompanying this great work the bulk are by the 'Heliotype' process, which is much more successful in its results than the half-tone blocks. Those plates giving views of distant reefs are only a monotone, and, as pictures, are not a success. It is possible that the lens of the camera employed was not well adapted for distant landscapes.

The near views of scenery, on the contrary, are very beautiful, and many of them most charming both for the rock-structures and the vegetation.

We heartily commend this grand work to the attention of our readers as one of the most valuable contributions yet made to the general history of coral reefs.

III.—Brief Notices.

Queensland.—Bulletin 18[2] of the publications of the Geological Survey of Queensland contains, amongst other matter, No. 180, Geological Survey Report, which is of a most interesting nature, dealing with a land of which little is known. In it Mr. C. F. V. Jackson writes a "Report on a visit to the West Coast of Cape York Peninsula and some islands of the Gulf of Carpentaria; also reports on the Horn Island and Possession Island Goldfields, and the recent prospecting of the Cretaceous Coals of the Cork District" (1902). Some midden heaps near Albatross Bay are noticed, from 20 to 30 feet high and stretching for several hundred yards, also large deposits of pisolitic iron-ore at the Batavia River, and some recent calcareous beds overlying Desert Sandstone of Upper Cretaceous age at Sweers Island. There is in addition much information of a general character concerning this district.

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[1] This work has been admirably carried out at Funafuti, and we are anxiously looking for the publication of the results of the examination of the cores, which has been carried out by Professor J. W. Judd, Dr. G. J. Hinde, and Dr. E. W. Skeats.

[2] For earlier notice see Geol. Mag., July, 1903, p. 336.

Other Queensland publications recently received are: Annual Report for 1901; Coal Beds of Waterpark Creek, by W. E. Cameron, described as Trias-Jura in age, resting on Permo-Carboniferous slates; the Kangaroo Hills mineral-field, by W. E. Cameron, 1901, mainly economic, but with a geological map on which the age of the sedimentary beds is "undetermined"; and the Burrum Coalfield, by W. H. Rands (1886) and L. C. Ball (1901), 1902, with maps and plans. Here, again, the age of the coal-bearing beds is said to be Lower Trias-Jura. Fossils are apparently scarce in species, though plentiful in numbers, but no fossils have been found in the surface rock, and its age is therefore unknown, though in places it resembles the Maryborough Desert Sandstone, which is of Upper Cretaceous age.

MELBOURNE, NATIONAL MUSEUM.—Mr. Frederick Chapman has, we are informed, already made great strides towards the general arrangement of this Museum. We notice that in the Proceedings of the Royal Society of Victoria he has begun the description of "New or little-known Victorian Fossils in the National Museum, Melbourne." Those described in part i, range from Plantæ to Crustacea, and include an interesting Crinoid to which the name *Helicocrinus* has been given, and a new Phyllocarid, called by Mr. Chapman *Rhinopterocaris*. A great deal may be said as to the advisability of giving local names to forms by reason of supplying a clue to their locality, but we think Mr. Chapman would be more kindly thought of if he refrained from calling any more fossils '*wooriyallockensis*'!

NORTH OF ENGLAND GEOLOGY.—Bibliographies of the geology of the North of England have appeared in *The Naturalist* since 1884. The one recently published by Mr. Thos. Sheppard for the year 1900 contains some 200 entries, to the majority of which are appended short notes of contents. These local lists are of considerable value, and we should like to see a special effort made to keep them more up to date.

PETROLEUM.—M. Romain Zaloziecki has published "O nitrowaniu nizej wracych frakcyj ropy galicyjskiej," in *Bull. Intern. Sci. Cracovie* (Avril, 1903). This may be englished as follows: "On the nitration of fractions of Galician petroleum of which the boiling point is slightly raised." The paper is in French. A further article on the petroleum industry in Peru during 1901 will be found in Spanish in the *Boletin del Cuerpo de Ingenieros de Minas del Peru*, a new periodical of which Nos. 1 and 2 (1902) have just reached us. It is issued at Lima by the Ministerio de Fomento.

Medullosa.—Those who study fossil botany seem rather to work from a morphological than a systematic standpoint. Hence such works as Mr. Arber's "On the roots of *Medullosa anglica*" (Ann. of Botany, xvii) are of not infrequent occurrence. The first British specimens of *Medullosa*, one of the Palæozoic Cycadofilices, were described by Dr. Scott as recently as 1899. From sections of the roots of this plant, preserved at Cambridge, and which Mr. Lomax considers came from the Lower Coal-measures of Hough Hill Colliery, Stalybridge, Lancashire, Mr. Arber has been enabled to supplement Dr. Scott's very complete account. The result of this examination of fresh material has revealed a more complete knowledge of the thin-walled tissues which lie between the xylem and the periderm. The most noteworthy points are, the presence of a thin zone of phelloderm, the structure of the phlœm, and the discovery of lateral sieve-plates in the phlœm elements of both the stem and the roots. In the phlœm of *Medullosa* we have another point of agreement between it and *Heterangium*. The structure of the root of *Heterangium tiliæoides* is at present unknown, but the phlœm in the roots of *Medullosa anglica* closely resembles that of the stem in the former species. Excellent figures are given.

Peru.—Under the authority of Don Eugenio Larrabure y Unanue, Minister of Foreign Affairs in Peru, Mr. Eduardo Higginson, Consul of Peru, has issued a new map of the republic. This is not in any way geological, but will be found of great value by those who seek to localise specimens from that interesting country. The back of the map contains much printed matter of interest, and that relating to geological matters will be found under the heads of Guano, Artesian Wells, and Mineral Wealth.

REPORTS AND PROCEEDINGS.

I.—The Palæontographical Society of London.

Annual General Meeting, June 26th, 1903. — Dr. Henry Woodward, F.R.S., President, in the chair. The Secretary read the fifty-sixth Report of the Council for the year ended 31st March, 1903. It referred to the satisfactory condition of the Society, and the unusually large volume, with varied contents, which had been issued for the year 1902. This volume contained instalments of the monographs of Pleistocene Mammalia (Cave Hyæna), Cretaceous Fishes, Cretaceous Lamellibranchia, and Graptolites. The receipts were £91 3*s*. 5*d*. less than those of the previous year, and there had been several losses by death and resignation. Special reference was made to the death of the Rev. Thomas Wiltshire, D.Sc., who was for thirty-seven years Secretary of the Society. The withdrawal of several small libraries was noticed, and an appeal was made for new personal subscribers. Besides the monographs of Cretaceous and Carboniferous Mollusca, Graptolites, Cretaceous and Carboniferous Fishes, and Pleistocene Mammalia, other works were also in active progress, among these monographs of Trilobites and

Cornbrash Fossils. The officers were re-elected, namely, Dr. Henry Woodward, President; Mr. Etheridge, Treasurer; and Dr. Smith Woodward, Secretary. The new members of Council were Professor Boyd Dawkins, the Rev. J. F. Blake, Dr. Wheelton Hind, and Mr. F. W. Rudler.

II.—The Geological Society of London.

June 24th, 1903.—J. J. H. Teall, Esq., M.A., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "On a Transported Mass of Ampthill Clay in the Boulder-Clay at Biggleswade (Bedfordshire)." By Henry Home, Esq. (Communicated by Horace B. Woodward, Esq., F.R.S., F.G.S.)

The section described was exposed in the construction of a well two miles south-south-east of Biggleswade railway station. Under 10 feet 6 inches of soil and Boulder-clay, the Ampthill Clay was penetrated for 67 feet, resting on Chalky Boulder-clay, fine silty clay, disturbed Gault, and Lower Greensand. The clay is lithologically identical with the Ampthill Clay with its selenite crystals, and contains *Ammonites excavatus*, often covered with Serpulæ, but no examples of *Ostrea deltoidea.* The boulder was probably an outlier situated in Oxford Clay at a level high enough to be ploughed into by the agent which formed the Glacial Drift. The distance from which it was moved may not have been greater than a mile or two, but on this point no definite opinion can be expressed. The Septaria in it have a dip of 9°. The extent of the mass has not yet been ascertained.

2. "The Rhætic and Lower Lias of Sedbury Cliff, near Chepstow." By Linsdall Richardson, Esq., F.G.S.

The chief portion of the cliff-section described has a direction north-east and south-west; the dip of the beds not exceeding 3° to the south-south-east. The section is as follows:—

			ft.	in.
Lower Lias.		Based on a conglomerate composed of fragments of Cotham Marble	37	1
Upper Rhætic.	2.	Greenish-grey, chiefly laminated shales... ... 2 feet to	3	4
	3.	*Estheria*-bed		4 to 12
	4.	Greenish-grey shales	3	5
Lower Rhætic.	*5a.*	Black, laminated shales	2	4
	5b.	Hard, blackish-blue limestone	0	5
	6.	Black, earthy shales, full of shell débris	0	6
	7.	Hard, slightly pyritic limestone	0	6
	8. 9. 10.	Black, selenitic shales	5	4
	11.	Firm, black, thinly laminated shales	1	2
	12.	Black, earthy shales	0	6
	13. 14.	Alternating layers of sandstone and shale, the former with small quartz-pebbles	0	8
	15.	Sandstone (Bone-bed), coarse and calcareous, with masses of 'Tea-green Marl'	0	4
Upper Keuper.	I.	'Tea-green Marls' with hard bed of marlstone	10	3
	II.	Red Marls, angular fracture	56	0

3. "Notes on the Lowest Beds of the Lower Lias at Sedbury Cliff." By Arthur Vaughan, Esq., B.A., B.Sc., F.G.S.

The author examined this section in company with Mr. Richardson. The two chief points of interest are, the relation of the basal conglomerate to the Cotham Marble and White Lias of neighbouring districts, and the examination of the faunal sequence, with a view of testing the absolute value of Ammonite zones. The conglomerate resembles the so-called 'False Cotham,' and both may be explained by the breaking up of Cotham Marble, in one case at intervals during a continuous phase of deposition, in the other after the phase of deposition which produced it had entirely ceased at that place. The break thus represented in the Sedbury area may be considered to correspond roughly to the time of deposit of the White Lias in the areas to the south and east. The succession of events appears to require a tilting, the axis of rotation being a nearly east-and-west line a little south of Sedbury, with gradual and uniformly increasing depression towards the south, followed by a period of horizontal equilibrium. On the other hand, the succeeding *Psilonotus*, *Angulatus*, and *Arietes* zones indicate a gradually increasing depression towards the north with a change of axis.

A range-graph is given, showing the times of appearance and disappearance, the abundance or rarity, of several fossils within and below the zone of *Ammonites psilonotus*; and on account of the beginning of five forms at a given horizon and the disappearance of several forms immediately below it, this level is chosen as the base of the zone of *A. psilonotus*, rather than the point of appearance of *A. planorbis*, 4 feet higher up. It is hoped that the construction of range-graphs will be of use in testing the value of a series of Ammonite ages as divisions of relative time.

III.—Royal Microscopical Society.

Some Ideas on Life. Being the Presidential Address to the Royal Microscopical Society by Henry Woodward, LL.D., F.R.S., late of the British Museum (Natural History). From the Journal of the Royal Microscopical Society, 1903, ser. II, vol. xxiii, pp. 142–157.

AFTER some prefatory remarks Dr. Henry Woodward said:—Perhaps the oldest themes which are to be found broidered into the later history, legends, and traditions of all races of mankind are those which relate to the creation of the world and its inhabitants and their destruction by the Flood.

Apart from the sacred writings of the Hebrews, we have Assyrian tablets and Egyptian hieroglyphs, while the Greeks have given us in charming fables, and in many versions, the account of Prometheus forming men of clay and stealing fire from the chariot of the sun to endow them with life; of Deucalion and Pyrrha rescued from the flood, and afterwards renewing the human race by throwing stones behind them, which became men; of Epimetheus and his wife Pandora, and the story of the sealed box, which she was forbidden to open. and how the curiosity of Pandora caused her to raise the lid, when all the evils incident to humanity poured out, and the only good remaining was Hope, which has been the solace of mankind ever since.

But leaving the regions of classical and mediæval myths, and even passing over unnoticed the earlier writers and philosophers—whose observations, though often very good, ended frequently in the fabulous and mysterious, or were intermingled with gross errors resulting from ignorance of astronomical laws and cosmical and chemical effects—we come, in 1669, to the observations of Steno, a professor of the Padua University, who compared fossil shells with recent, and showed that the two were often specifically the same—that sharks' teeth from the hills of Rome were like those of a shark now living in the Mediterranean.

The eighteenth century gave birth to many able philosophers and also to many writers having a distorted vision resulting from a firm belief in the literal acceptance of the Mosaic cosmogony, into which they constrained their facts and observations to fit.

Gesner, a Swiss observer, in 1759 demonstrated, by comparing past physical changes with those now in progress, that elevation of mountains and the wearing away of ravines and valleys must have occupied tens of thousands of years to accomplish.

Dr. John Woodward (1665–1729) insisted on the theory that all deposits resulted from the Noachian deluge, and that their materials and fossil contents were arranged by *gravitation*, the heaviest at the bottom. He did one excellent thing, he founded in Cambridge the Woodwardian chair of geology, which has now become a great centre for the teaching of modern geology, but was originally designed to ensure the delivery of a sermon annually, to confound the doctrines of Dr. Camerarius, of Tübingen, and all his works, because he differed from the views of Woodward.

Some of the writings of the Italian naturalists at this time were most brilliant and advanced, but the lack of frequent intercommunication between men of science 150 years ago prevented the wide spread of intellectual ideas.

Amongst the most able writers in this country was James Hutton (1726–1797), of Edinburgh, whose "Theory of the Earth," etc., was the foundation of Lyell's "Principles of Geology" and many other later writings. His views, based on observations, were clear and convincing to all studious minds:—

"The ruins of an older world are visible in the present structure of our planet; and the strata which now compose our continents have been once beneath the sea, and were formed out of the waste of pre-existing continents. The same forces are still destroying, by chemical decomposition or mechanical violence, even the hardest rocks, and transporting the materials to the sea, where they are spread out and form new strata analogous to those of more ancient date. Although loosely deposited along the bottom of the ocean, they become afterwards altered and consolidated by volcanic heat, *and then* heaved up, fractured, and contorted."

In William Smith (1769–1839) we have a man of humble origin, born at Churchill in Oxfordshire, who, by force of will and industry, trained himself and became a mineral surveyor and geologist of no mean order. He not only mapped out the geology of England and Wales in a most admirable manner, but discovered a great and original principle, which has stood the test of over 100 years of subsequent geological field-work, namely, that the relative age of sedimentary deposits can be determined with certainty by their organised fossil contents. This principle, which he was able to prove to demonstration over wide areas and in hundreds of instances, together with the excellent map which he produced, obtained for him from Sedgwick the title of "Father of English Geology." Had William Smith been as able a writer as he was a brilliant observer in the field and mapper, his name would have been more widely known than it is. One of his geological contemporaries was Samuel Woodward,[1] of Norwich (1790–1837). Suffice it to say that with a succession of men like Sedgwick, Conybeare, Buckland, Phillips, Murchison, Lyell, Scrope, Fitton, De la Beche, Griffiths, Portlock, Prestwich, Ramsay, Geikie, geology has progressed enormously in the past 100 years, and is now one of the most popular sciences of the day.

From the birth of orderly stratigraphical geology has arisen the cognate science of Palæontology, which treats of all fossil remains, and takes note of their succession in the rocks as well as their zoological position among living organisms.

But since the publication of Darwin's "Origin of Species," now forty years ago, a new and ardent school of zoologists and botanists have entered the field of palæontology, who, whilst they ignore entirely the advantage which the stratigraphical geologist derives from fossils, looked at from the chronological aspect, are nevertheless eager to possess themselves of the palæozoological evidence they furnish, which is in fact the key to open the lock of the casket that holds the secret of the origin of species, and even, they believe, of the beginning of life on the earth, a secret they are as eager to learn as that for which our first mother Eve bartered Paradise, or that which excited the curiosity of the Greek Pandora, or the unhappy wives of Bluebeard.

Although I may not deceive you with promises to disclose the very beginning of life, I may at least be able so far to lift the lid of the casket as to give you a glance at some of the earliest appearances of groups of living organisms, and point out a few which have persisted over vast periods of time, and others which, though of great importance at one time (like some of our celebrated human families), have now entirely disappeared.

While upon the subject of the evolution and extinction of life-forms I may be permitted to refer you to a very able paper which has lately appeared,[2] by Mr. C. B. Crampton, on this subject.

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[1] Author of a work entitled "Outline of the Geology of Norfolk," 1833, "A Synoptical Table of British Organic Remains," 1830, and about thirty other memoirs and works.

[2] Proc. Roy. Phys. Soc. Edin., vol. xiv, p. 461; read March 20th, 1901.

I will now only venture to glance at some of the Invertebrata; leaving the Vertebrata to be discussed upon another occasion.

"In the first place" (Mr. Crampton writes) "the lowly-organised groups have persisted in spite of the gradual evolution of more and more highly-organised forms, and this must be due in large measure to their rapid growth and reproductive powers.

"That groups appear to have a shorter range in time as they acquire a higher degree of organisation.

"That living forms of groups that are dominant at the present time rarely show ancestors of such great specialisation as themselves.

"That forms that are now isolated in their zoological affinities, and bordering on extinction, are generally highly specialised in some direction, but often show signs of degeneration, and usually have ancestors of greater specialisation during some former period of dominance. A few, at any rate, seem to show a smaller degree of fertility than might be expected.

"Other forms which have come down to us from a distant period with small amount of change, or with very gradually-acquired specialisation, often show a great power of resistance to death. They are also generally extremely fertile.

"That extinct groups seem almost invariably to have acquired a great degree of specialisation during their period of dominance.

"That the more specialised genera and species of groups tend to have a shorter range in time than the less specialised, although they frequently appear to have temporarily acquired a greater dominance.

"When a group shows very quickly-acquired variation and specialisation its range is usually very restricted.

"That the later forms in extinct groups frequently show signs of degeneration, and sometimes a more primitive organisation than the most specialised forms, possibly owing their persistence to their slower specialisation.

"That long retention of primitive characteristics, or a great degree of stability and want of variation, has been usually associated with a long range in time.

"That higher groups do not spring from the most specialised forms of the parent groups before them in time, but from some generalised form in those groups which had retained a more primitive organisation." And, lastly, I would add—

That those forms which have persisted through long past periods of geological time, have also an extremely wide geographical distribution at the present day. As might naturally be expected, it is the *lowly-organised* forms which show the longest geological history.

I. Protozoa.—Radiolaria are found throughout the whole geological series and are world-wide in their distribution.

Of the Foraminifera about two-thirds out of 2,000 species occur fossil. The longevity of some genera is truly remarkable, e.g., *Lagena, Nodosaria, Textularia.* The first two range from Silurian, and the last from Carboniferous times to the present day. *Fusulina* and *Schwagerina* are world-wide in their distribution in Carboniferous time, forming entire beds of limestone. (They are, however, confined to the Carboniferous.)

Several giant species of *Nummulina* occur in early Tertiary times.

II. Porifera (the Sponges).—The Lithistid and Hexactinellid Sponges have existed since Cambrian times. The Calcispongiæ appear in late Palæozoic times, and only become important in the Mesozoic period.

III. Cœlenterata: (1) Hydrozoa.—The Graptolites are world-wide in their distribution in early Palæozoic time; they are enormously abundant and varied, and disappear at the end of the Silurian period. *Dictyonema*, a doubtful Graptolite, extends from the Cambrian to the Devonian.

(2) Anthozoa.—Of the Corals the Rugose and Tabulate corals are confined to the Palæozoic rocks.

The Hexacoralla are first seen in the Trias and continue to the present day. *Zaphrentis*, *Petraia*, *Clisiophyllum*, and *Strephodes*, all simple types of Rugose corals, range from the Silurian to the Carboniferous age. The same range is found for *Cyathophyllum* and *Diphyphyllum*, both of which are compound forms. Of the Hexacoralla four genera range from Jurassic to Recent.

Of the Tabulate corals (among the Rugosa) *Favosites* and *Syringopora* range from Silurian to Carboniferous times.

The existing corals belong to the Madreporaria, the Fungida, and Perforata, and have no Palæozoic representatives, but the Secondary and Tertiary deposits have yielded a large number of these forms. The composite Madrepora include a vast number of forms, and range from the Eocene to the present day.

IV. Echinoderma.—Of the Echinoderma the extinct groups, the Cystoids and Blastoids, only lived in the Palæozoic period. Of Cystoids 50 genera and 250 species are known, and of Blastoids 19 genera and 120 species are recorded.

The Crinoids appear to have declined ever since their maximum development in Palæozoic times. *Ichthyocrinus* ranges from the Ordovician to the Carboniferous. *Taxocrinus* has the same range. Of later forms *Pentacrinus*, *Extracrinus*, and *Antedon* have persisted from the beginning of the Mesozoic period with very little change.

Starfishes range from the Cambrian to the present day.

Echinoids: regular forms like *Cidaris* have existed since the Trias. *Echinocorys* and some other irregular forms appear in the Cretaceous, but many of the genera quickly became extinct. But both regular and irregular forms have continued on to the present time.

V. Polyzoa ('Sea-Mats').—The Polyzoa date back to the Ordovician. Of the Cyclostomata, *Stromatopora* and *Berenicea* range through the whole time to Ordovician. Many living genera range back into Mesozoic times.

The Monticuliporoids, a peculiar group, perhaps related to the Polyzoa, were dominant in Ordovician and Silurian times, but doubtfully survived the Palæozoic period.

Of the Cryptostomata such genera as *Fenestella*, *Polypora*, *Rhabdomeson*, and their allies are Palæozoic.

The Chilostomata, forming the bulk of living Polyzoa, date back to the Jurassic period.

VI. Brachiopoda. — The Brachiopoda have their maximum development in Palæozoic times. ***Productus, Spirifer, Pentamerus, Cyrtia, Merista, Uncites,*** and ***Stringocephalus*** show not only great abundance and extraordinary specialisation of forms, but also remarkable variety of shape, size, and condition of their brachial supports. They have a comparatively short range in time, both in genera and species.

The long-winged Spirifers, dominant in the Devonian, were rapidly extinguished, but the simple ***Spirifer glabra*** ranges from the Devonian into the Carboniferous. Any striking peculiarity of growth or size seems to be followed by rapid extinction.

In the Mesozoic period both genera and species are much reduced in numbers, the forms chiefly belonging to the persistent ***Terebratula*** and ***Rhynchonella*** types, with slight variations in their shell-markings.

With these are some exceptional forms, such as ***Lyra, Magas, Kingena, Trigonosemus,*** strictly Cretaceous; while a few others, as *Pygope, Dictyothyris* (specialised *Terebratulæ*), have a limited range in the Jurassic period. From the Lower Palæozoic period genera like ***Lingula, Crania,*** and ***Discina*** have continued on, and are living now. Such forms may be truly termed persistent types. In this division hermaphroditism (so rare in this class) occurs. ***Lingula*** shows great resistance to death, surviving after being out of water and in a dry condition for some time.

VII. Vermes (Worms).—Worms being all ***soft-bodied animals*** are seldom found in a fossil state. Their former existence is, however, proved by their tracks, burrows, and castings which they have left in the sedimentary rocks ***from the Cambrian to the present day.*** Their chitinous teeth and jaws have been exhibited by Dr. Hinde, F.R.S., before this Society, and described and figured in the Quart. Journ. Geol. Soc. London, 1879, 1880, and in the Transactions of the Royal Swedish Academy.

Many species construct tubes. These variously-formed cases (called *Serpulæ*) are common in many formations, but do not disclose much information about the structure of the animal itself.

They admirably illustrate the persistence ***in time*** of very simple and lowly organised forms, having bodies composed of a large number of similar segments (often capable of subdivision), and possessing moreover great powers of reparation and reproduction and resistance to death.

VIII. Mollusca. — In the Mollusca, amongst the Lamellibranchiata, there are many persistent types showing very small amount of variation. E.g., *Solenomya* has persisted since Carboniferous times, and *Nucula* from the Silurian onwards. Both belong to the 'Protobranchiata' forms, with simple gills and a sole on the foot for creeping upon—not a mere digging foot. In contrast to these are the Rudistes, such as *Diceras*, Upper Jurassic; ***Requienia,*** *Monopleura, Caprina, Sphærulites,* and *Hippurites*, etc., from the Cretaceous. These peculiar molluscs had a world-wide distribution, and occur in such numbers that beds of limestone are often built up of their shells. *Chama*, which represents them, has continued to the present day, but is less specialised.

Trigonia is not only a persistent genus, but exhibits great resistance to extreme variation, save in minor matters of shell-ornament. It ranges from Trias to recent, and has a world-wide distribution. There are three species living in Australia, and at least 100 species extinct.

In the Scaphopoda the curious tubular genus *Dentalium* ranges from the Ordovician to the present day. There are many species, but little variation from the type.

The multivalve Chitons extend also from Ordovician times to the present, but are never common in a fossil state. Only 70 species have been described from all known horizons. They are more abundant in modern seas, more than 200 species being now living.

The Pteropods (proper) only date back to the Cretaceous. The earlier forms, known as *Tentaculites*, *Hyolithes*, *Conularia*, are very doubtfully related to the Pteropoda. We have *Tentaculites* in Silurian and Devonian rocks; *Hyolithes*, Cambrian to Permian; and *Conularia*, from Ordovician to Lias: both the latter are very persistent types.

In the Mollusca—Gasteropoda—*Patella*-like forms have existed from early Palæozoic times. Walcott has figured 6 species of *Scenella*, 8 species or varieties of *Stenotheca*, and 1 of *Platyceras*, from the Lower Cambrian of North America. *Capulus* has persisted from Cambrian times to the present day.

The remarkable genus *Pleurotomaria* also ranges from Cambrian to recent, living in Japan and in the West Indies, and is represented by 4 or 5 species recent, 11 Tertiary, 575 Secondary, and 570 Palæozoic forms.

The Nerineidæ have very specialised shells in the structure of the columella; their range is also very brief. There are 150 species recorded from Mesozoic strata.

The Pulmonifera, Land-Snails, range from the Coal-measures to recent.

Among the Cephalopoda, the Nautiloid type is remarkable for its persistence since Cambrian times. Many specialised forms, showing extreme variety of growth and shell-structure, have branched out from this stock during its dominance in Palæozoic times, but these have in turn all died out. Of these, the simple genus *Orthoceras*, with its long straight shell, had the greatest range, viz. from the Cambrian to the Trias; other forms of Cephalopod shell have fairly long ranges and show remarkable varieties of shell-structure.

The Ammonites, which range from the Trias to the Chalk, exhibit almost endless variety in shell-ornament within certain limits, and have a world-wide range in Jurassic times, branching out into more than 600 species. In the Cretaceous period (before their disappearance) they put on most singular and remarkable developments of shell-variation, *Crioceras*, *Scaphites*, *Ancycloceras*, *Helicoceras*, *Toxoceras*, *Baculites*, *Ptychoceras*, *Hamites*, *Turrilites*; then they disappear entirely. We do not know the animal in Ammonites.

The Belemnitidæ range from the Trias to the Cretaceous. The guard in most genera is large and dense, whilst the chambered portion, or 'phragmocone,' is small and rudimentary. But *Aulacoceras* of the Trias has a large phragmocone, the guard being quite small.

The Belemnites appear to have been gregarious (like their modern congeners the 'Squids'), entire beds in the Lias being composed of their guards at Whitby in Yorkshire, Lyme in Dorsetshire, and other localities in the central counties. More than 100 species have been described.

Possibly *Spirulirostra*, of the Tertiaries, and the recent *Spirula* may be survivors which have gradually dispensed with the guard to the shell, so characteristic of the Belemnites proper.[1]

IX.—The following table shows the range of the Arthropoda in time:—

ARTHROPODA.

A.—CRUSTACEA.

I. ENTOMOSTRACA. (1) BRANCHIOPODA.

Order 1. PHYLLOPODA.		
	Apus	Cambrian to recent.
2. PHYLLOCARIDA.		
	Hymenocaris, *Ceratiocaris* (*Nebalia*[2])	Ditto.
	Estheria	Devonian to recent.
	Cheirocephalus	Tertiary to recent (fresh-water)
	Artemia	Ditto (saline).
3. CLADOCERA.		
	Daphnia and its allies	Probably all recent.
	(The *Ephippia* winter eggs of *Daphnia* have been found fossil by Mr. Clement Reid, F.R.S., in the Forest Bed series of Norfolk.)	
4. OSTRACODA.		
	Cypris, *Candona*, *Cythere*, etc.	Palæozoic to recent.
5. COPEPODA.		
	Cyclops, etc.	Not found fossil.
	Many other families are not represented in a fossil state.	

II. MALACOSTRACA.

1. PODOPHTHALMA.		
	Brachyura	Jurassic to recent.
	Macrura	Carboniferous to recent.
	Schizopoda	Ditto (*Palæocaris*).
	Stomapoda	Devonian or Silurian to recent.
2. EDRIOPHTHALMA.		
	Cumacea	Carboniferous to recent.
	Isopoda	Magn. L. to recent.
	Præarcturus	Devonian (?).
	Amphipoda	Carboniferous (?).

III. GIGANTOSTRACA, Haeckel.

TRILOBITA		Cambrian to Carboniferous.
MEROSTOMATA.		
	Eurypterida	Ditto.
	Xiphosura	Silurian to recent.

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[1] I am desirous to mention here that for the above summary, from the Protozoa to the Mollusca, I have largely made use of Mr. C. B. Crampton's statistics with some modifications from my own notes and other sources of information.—H. W.

[2] Recent analogue. Probable progenitor of Decapoda.

IV. CIRRIPEDIA.

(Sessile)	
Balanidæ (*Brachylepas*)	Cretaceous to recent.
(Pedunculated)	
Lepadidæ (*Turrilepas*)	Silurian to recent.

B.—ARACHNIDA.

Scorpionidæ.	
(Scorpions)	Silurian to recent; world-wide distribution.
Palæophonus	Up. Sil., Scotland, Gotland, and Illinois, U.S.
Eophrynus	Carboniferous only.

C.—MYRIOPODA.

Euphoberia and allies	Coal-measures to recent.

D.—INSECTA.

Palæodictyoptera.	
Blatta	(Silurian ?) to recent.
Eugereon, etc.	Permian to recent.
Orthoptera	Coal-measures to recent.
Neuroptera	Ditto.

Summary.—And now, "let us hear the conclusion of the whole matter."

The whole history, since the beginning of life on the earth, shows a steady upward tendency (in fact, Evolution) in life as displayed in the Geological Record.

Extinct Groups.—Some forms appear, attain a more or less important position on life's stage, and then die out completely.

Of such are the once abundant Graptolites, which had their beginning in the Cambrian, their maximum in the Ordovician and Silurian, and then disappeared.

The Trilobites, which began in the Cambrian, attained their maximum in the Silurian, lived on into Carboniferous times, and then disappeared.

The Merostomata (*Pterygotus*, *Eurypterus*, *Stylonurus*, etc.) began in the Silurian, attained their maximum, lived on into the Devonian and Carboniferous periods, and then became extinct.

Persistent Groups.—Again we have *persistent forms* of which we seem to see neither the beginning nor the ending.

Of these we may name the Protozoa, embracing the Radiolaria and the Foraminifera, both persistent in rocks of all ages and well represented at the present day.

The Porifera (Sponges), which, though materially differentiated in the course of geological ages, have lived on through all time.

The Crinoidea (Sea-lilies), represented from Silurian times to the present day, but not nearly so abundant as in Palæozoic times.

The Starfishes (Asteroidea and Ophiuroidea), both persistent types from Silurian (or earlier) times to the present.

The Annelida, again, are met with in all strata and also living.

The Brachiopoda, beginning in the Cambrian, enormously developed in Silurian, Devonian, Carboniferous, and Secondary deposits, and still surviving in diminished numbers in modern seas.

The MOLLUSCA, represented in past time by the persistence of

Lamellibranchiata	Cambrian to recent.
Scaphopoda	Cambrian (?) to recent.
Chitonidæ	Silurian to recent.
Pteropoda	Cretaceous to recent.
Prosobranchiata	Cambrian (?) to recent.
Cephalopoda (in part)	Ordovician to recent.
Pulmonifera (*Zonites* and *Pupa*)	Coal-measures to recent.

The CRUSTACEA, represented in past time by persistent forms such as the

ENTOMOSTRACA—	
Ostracoda	Cambrian to recent.
Phyllocarida	,, ,,
(*Xiphosura*) *Limulus*	Silurian to recent.
The ARACHNIDA.	
Scorpionidæ (*Scorpio*)	Silurian to present day.
The MYRIOPODA	Coal-measures to recent.
The INSECTA.	
Neuroptera	Coal-measures to recent.
Orthoptera	,, ,,
Thysanura	,, ,,
Homoptera	,, ,,

Of newer groups the following which have appeared in later geological time may be cited :—

The *Bryozoa*	Carboniferous to recent.
The *Echinoidea*, or 'Sea-urchins' ...	,, ,,
The *Gasteropoda*	,, ,,
The *Decapoda*	,, ,,
The *Isopoda*, etc.	,, ,,

If we except such groups as the Crinoids, the Brachiopods, the Nautilidæ, the Xiphosura—which evidently attained their greatest maximum in the past, and, although still surviving, are now but a feeble folk—we shall notice that the modern Echinoids, Bryozoa, Mollusca, Lamellibranchiata, Gasteropoda (Siphonostomata and Pulmonifera), the higher Crustacea (Decapoda, Brachyura, and Macrura), the Isopoda, Stomapoda, etc., and our modern Insects, are far in advance of their 'forbears' in development, and this is especially true of all the chief existing forms of life.

Just as in the vegetable world our modern flora (with its wealth of flowering plants) is far more highly organised, varied, and beautiful than the vegetation of the past ages of the world, so is the associated fauna of to-day when contrasted with that of the past.

But, it may be asked, what prospect is there of arriving at the earliest known ancestor from which all these varied forms have been derived? What help does the geological record afford us? My duty, as your guide, is to inform you that our increased knowledge of the older rocks has not shown that we are nearer the fulfilment of the young biologist's dream, and the secret of Pandora's Box remains still undiscovered. We have not as yet reached the beginning of life.

In the oldest Cambrian of North America, Professor C. D. Walcott has shown the presence of some 61 so-called genera and 142 reputed species, embracing Sponges, Corals, Annelids, Graptolites, Echinoderma, Brachiopoda, Mollusca, lowly Crustacea, and Trilobites.

But, *after all our labours and strivings* to reach the beginning of all things, let us take comfort in this, that, like Pandora of old, we still have Hope left us in the Box (or shall we say *in the Rocks* ?).

Those Eozoic rocks which underlie our present oldest fossiliferous strata may yet yield to the geologist and biologist in the future an earlier and more primitive fauna and flora, just as the Lower Cambrian rocks have done for us in the past.

CORRESPONDENCE.

THE GEOLOGY OF GAVARNIE.

Sir,—The latest number of the *Bulletin des Services* (No. 93) of the French Geological Survey establishes in 300 elaborately illustrated pages a new stratigraphical paradox, confirming those already noticed in your pages. Having mapped the entire district in question on a larger scale some years ago, and having again verified the facts on the spot, I would point out the decisive features recognizable by the practical geologist.

At Gavarnie the tourist observes a gigantic precipice which is the northern edge of the Secondary and Tertiary sheet that composes the Spanish Pyrenees. Its abrupt contact with the Palæozoic rocks traversed by the entire road of approach, and the consequently sudden opposition between the character of erosion exhibited by the Cirque, excavated in the Secondary rocks, and the very different erosion of the Palæozoic, is unique in the Pyrenees.

In the *Bull. Soc. Geol.* of 1868 I first figured the fault of contact, and I have since traced its outcrop through the Cascade Hotel, the Port de Pailla, the Port Neuf de Pinede, and the Port de Gavarnie. *In front of it,* the tourist perceives a gigantic wedge of white limestones which are visibly continuous with the Devonian limestones of the Palæozoic valley in which he stands. This wedge forms the Pic Rouge de Pailla, and there contains a lead lode such as abound in the Palæozoic and are unknown in the Upper Cretaceous of the Pyrenees. Throughout its base, hollow concretions of chert and calcite abound, whose broken sections are easily confounded with Rudists and other shells; but the only authentic fossil I have found in it was a fairly characterized *Atrypa reticularis* at a few feet from the fault. The pseudo-fossils have for more than thirty years been mistaken for Rudists such as abound in the glacial blocks abundantly dispersed from the overhanging Secondary precipice. The author in question has accepted the consecrated error, and has inadvertently classed the Palæozoic wedge as a portion of the Secondary that lies beyond the fault. Inevitably, he is hence compelled to class the visible continuance of that wedge to the north as a tongue of Cretaceous extending between the granite base and the remaining Palæozoic rocks of the French valley.

His efforts to confirm the initial illusion are ingenious and inevitable. As type of the structure he imagines, he selects a section east of Gedre, where he himself admits that the Devonian limestone directly rests upon the granite. At the point he figures there is a thin intercalation of Silurian, but only the white and fissile surface of the granite can be mistaken for any independent limestone. That granulitic surface has certainly misled him in his sections of Heas; and in general he has taken for a regular outcrop of limestone the very regular band of fallen and glacial blocks which skirts the steep talus of the Silurian schist at the foot of the precipices of Devonian limestone. Among these chaotic blocks I have found no Rudists in place, but plenty in transported fragments. At the end of the Estaubé valley the confusion is repeated between the Secondary precipice and the Palæozoic wedge, here limited by a friction breccia.

In following a phantasm, the author has ignored the fact that the limestone he classes as Cretaceous descends abruptly in thin sheets both at the bridge of Gavarnie and at two kilometres to the south of it, these sheets being pinched between the granite to a depth beneath the floor of the valley. Strongly metamorphosed and visibly intersected by granite veins, these sheets prove that the granite was both active and flexible after the deposition of the supposed Cretaceous. At Bareilles the author has figured as a limited projection a third similar sheet. Here I formerly described, as undoubtedly in place, circular sections which I compared to the Jurassic corals I had found at the Col de l'Espandels, west of Argeles. But the author himself figures the limestone of the Col in question as Devonian, and I have ascertained that the apparent fossils of Bareilles are mere sections of pipes and other concretions of calcite.

The paradox in question hence arises from common illusions and the existing obstacles to their discussion. It is also an attempt to justify and excuse the former classification of the *dalle* limestone as Cambrian, because beneath the Silurian. In view of the fact that the official map of 1890 is proved entirely wrong by the new survey here in question, it should be remembered that the said map was in entire defiance of local observation.

Between the present paradox and the case of Eaux Chaudes an analogy is suggested by ignoring the fact that the fossils are there both specifically determinable and visibly in place; and the further fact that the Cretaceous there penetrates, vertically or reversed, from the surface, and accompanied by numerous ophites along its contact with the Palæozoic. At Gavarnie the fossils are worthless, the stratigraphy figured is in contradiction to salient facts, and the resulting paradox is itself an indication of the erroneous observation demonstrable on the spot. The relations of the Secondary, as followed by the Spanish geologists and by myself to the Pic d'Anie and the Maladetta, are in flat contradiction to what is here imagined. It is unfortunate that the work in question ignores those relations on every side. Even in the only other inclusion of Secondary rocks figured and described, the author entirely ignores the presence of the extensive bands of ophite by which it is limited between Argeles and Arbeost. Supposed "fragments of the tests of Rudists" are only valuable when confirmed by unquestionable fossils or by stratigraphic identification with adjoining fossiliferous bands.

CAUTERETS, *July* 18, 1903. P. W. STUART-MENTEATH.

THE

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ORIGINAL ARTICLES.

I.—On Homœomorphy among Fossil Plants.

By E. A. Newell Arber, M.A., F.L.S., F.G.S., Trinity College, Cambridge; University Demonstrator in Palæobotany.

Students of palæobotany, when concerned with casts and impressions of fossil plants as distinguished from petrifactions, have often to face difficulties in the course of their examination of such remains, some of which are peculiar to this branch of palæontology. Even when a large number of specimens of any particular type of foliage, or other organs, are available for comparison, it is often difficult to decide how far one set of casts and impressions can be regarded as distinct from another. Authorities differ in their ideas of the aggregate of differences necessary to constitute genera and species. This difficulty, although common to the systematist in the study of recent plants, is greatly intensified when dealing with fossils, on account of the fragmentary nature of the evidence.

To take an illustration. Among Upper Carboniferous fern-like plants none are perhaps more frequent in British rocks than *Neuropteris* and *Alethopteris*, types of foliage in all probability belonging to members, not of the true ferns, but of the Cycadofilices. In these genera the habit of the frond is extremely well marked and characteristic, and they are regarded as good form-genera. But there also occur, frequently in the Continental Coal-measures, though more rarely in the Carboniferous rocks of this country, two other genera, *Linopteris* (also known as *Dictyopteris*) and *Lonchopteris*, which correspond exactly with *Neuropteris* and *Alethopteris*, respectively, except in one remarkable detail. In *Linopteris* and *Lonchopteris* the secondary nerves of the pinnules anastomose among themselves, forming a regular network, whereas in the genera first mentioned no such reticulations occur. This parallelism extends also to species within the genera. As Zeiller[1] has pointed out, *Linopteris Brongniarti*, Gutbier, corresponds closely in habit to *Neuropteris gigantea*, Brong., and *L. Germari* (Giebel) to *N. heterophylla*, Brong. The question arises how far the presence or absence of a single character, such as the anastomosis of the secondary nerves, should be regarded as of systematic value.

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[1] Zeiller: "Éléments de Paléobotanique," 1900, p. 108.

To take another illustration. In the Permo-Carboniferous rocks of India and the Southern Hemisphere there occur an abundance of fronds of two genera, *Glossopteris* and *Gangamopteris*. According to our present knowledge, the latter differs from the former, at least in the commoner species, only in the absence of a midrib, a character which we also know is not present in all fronds of undoubted Glossopterids.[1] Etheridge[2] has pointed out how closely certain fronds of these two genera resemble one another. What weight should therefore be given to a single point of difference, such as the presence or absence of a midrib?

Often also plants from widely separated areas, which may or may not be contemporaneous, bear a close resemblance to one another, although definite characters may exist which clearly distinguish them. This is the case with *Aneimites ovata* (McCoy) from Arowa, New South Wales (?Carboniferous), which so closely resembles *Rhacopteris inæquilatera* (Goepp.), a well-known British Lower Carboniferous plant, that it is a matter of dispute whether the two are not identical.[3]

Many other instances might be quoted. In *Dictyozamites*, a Lower Oolite genus recently described from Britain for the first time by Mr. Seward,[4] we have an interesting case of parallelism with *Otozamites*. Professor Zeiller[5] has also recently pointed out that the genus *Rhiptozamites* of Schmalhausen represented in the Permian of Russia may eventually prove to be distinct from the *Noeggerathiopsis* of Gondwana-land, which it so closely resembles.

These are illustrations of a common difficulty constantly present in palæobotanical study. Before further light is thrown on the affinities of such plants by the discovery of their fructifications, discoveries which will often in themselves remove the difficulty, it would appear that any help which can be given as to the meaning of these similarities of habit would be welcome. Such guidance may, I think, be found in recent progress in other branches of palæontology, especially in the elucidation of the Rhabdophora and the Jurassic Brachiopoda.

In an interesting paper published in the Quarterly Journal in 1895, Mr. S. S. Buckman[6] pointed out that in the Jurassic Brachiopods, and also to some extent in the Ammonoidea, close resemblances occur between species of different origin and descent.

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[1] Zeiller, Bull. Soc. géol. France, ser. III, vol. xxiv (1896); Seward, Q.J.G.S., vol. liii (1897), p. 318; Arber, Q.J.G.S., vol. lviii (1902), p. 9.

[2] Etheridge, jun.: Proc. Linn. Soc. N.S. Wales, ser. II, vol. ix (1894), pp. 240–1.

[3] Arber, ibid., p. 21; Kurtz, Q.J.G.S., vol. lix (1903), pp. 26 and 28.

[4] Seward: Q.J.G.S., vol. lix (1903), p. 217.

[5] Zeiller: Compt. rendu Acad. Sci., t. cxxxiv (1902), pp. 887–891.

[6] S. S. Buckman, "The Bajocian of the Mid-Cotteswolds," Appendix, 'Note on certain Brachiopoda': Quart. Journ. Geol. Soc., vol. li (1895), p. 456.

In a second paper,[1] published in 1901, a further account was given of very striking examples of parallelism of development among these fossils, which has resulted in the production of homœomorphs, and of the phenomenon of homœomorphy. Mr. Buckman has further shown that "various species of different stocks may either produce these developmental characters more or less contemporaneously, in which case such forms are called isochronous homœomorphs, or they may produce the characters at different dates—a later form simulating an earlier one—in which case they are called heterochronous homœomorphs."[2] The conception that two genera of distinct ancestry may, by parallelism of development, evolve a series of characters common to the two, which, as it were, overshadow their distinctive and ancestral characters, throws a flood of light upon difficulties such as those here described.

Almost immediately after the publication of Mr. Buckman's first paper, Messrs. Nicholson & Marr[3] showed that the same hypothesis holds good for the Graptolites, and will "explain the more or less simultaneous existence of forms possessing the same number of stipes, but otherwise only distantly related, if we imagine them to be the result of the variation of a number of different ancestral types along similar lines."[4]

This conception is, however, something more than a working hypothesis, for both Mr. Buckman, in the case of Jurassic Brachiopoda, and Messrs. Nicholson & Marr with regard to the Graptolites, have been able to trace out the steps whereby two lines of descent converge towards homœomorphy, and the theory of homœomorphy has thus already won considerable acceptance.

It has seemed to me that the hypothesis of homœomorphy may be of great service as a guide to the systematist in difficulties such as I have just described among fossil plants, as it has been found to be in other branches of palæontology. In such genera as *Neuropteris* and *Linopteris* some support may be found for such a view, but in the present state of our knowledge of fossil plants I very much doubt whether it is possible to demonstrate a series of intermediate types similar to those brought forward in regard to the Brachiopoda and Graptolites. It would, however, seem certain that if the phenomenon of homœomorphy is constantly borne in mind, that many and excellent proofs will be obtained as our knowledge of fossil plants increases. For the present, however, the theory as applied to fossil plants must remain as little better than a working hypothesis, the truth of which would seem to be exceedingly probable. Even now we are not without evidence in support of this view, for homœomorphy is exceedingly common among living plants. It is, of course, well known that many recent plants of the most diverse origin show strong superficial resemblances. We also know that in the vast majority of cases these are not true mimetic resemblances, as occur in the animal kingdom, but adaptations to common conditions of the environment. Numerous instances might be quoted, but it may serve to mention the fleshy succulent stems of such Xerophytes as *Euphorbia* (Euphorbiaceæ), *Cactus* (Cactaceæ), and *Stapelia* (Asclepiadaceæ), and the much divided leaves of such hydrophilous plants as the Batrachian *Ranunculi* (Ranunculaceæ), *Myriophyllum* (Haloragidaceæ), and *Hottonia* (Primulaceæ).[1] Indeed, it is fully recognised that plants which are highly adapted may, if found fossil, become a fruitful source of error to the palæobotanist.[2]

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[1] S. S. Buckman, "Homœomorphy among Jurassic Brachiopoda": Proc. Cotteswold Naturalists' Field Club, vol. xiii (1901), p. 231.

[2] Buckman: ibid., pp. 232–3.

[3] Nicholson & Marr, "Notes on the Phylogeny of the Graptolites": Geol. Mag., n.s., Dec. IV, Vol. II (1895), p. 529.

[4] Ibid., p. 537.

If, therefore, the theory of homœomorphy is permissible as a working hypothesis applicable to fossil plants, then we have not only some explanation of the phenomenon "of similarity in general with dissimilarity in details,"[3] which is common among such remains, but an indication of the possible diverse origin of such types. At the same time, it is necessary to guard against an undue application of a criterion of small differences, and consequently a large increase to the number of genera and species already recorded. It is necessary to remember that such small differences may be really due to the manner of preservation. But where good characters do exist, however much they may be overshadowed by general resemblances, the adoption of the theory of homœomorphy, even though it may not in all cases be a safe guide, would usually point to separation rather than to identification.

II.—On a Fossiliferous Bed in the Selbornian of Charmouth.

By W. D. Lang, B.A., British Museum (Nat. Hist.).

THE Charmouth district, situated in the south-west corner of Dorsetshire, consists of valleys in the Lias clays, separated by hills which are capped by Upper Cretaceous rocks, resting unconformably upon the Lias. Black Ven is the name of the cliff face bisecting one of these hills, which, lying between Charmouth and Lyme Regis, divides the valleys of the Char and the Lyme stream. Of this cliff, the lower 350 feet consist of Lias clays and limestones. Above this the succession of beds is explained by the following section:—

		Feet.
	4. Soil and subsoil, consisting chiefly of the weathered remains of the Chert beds in the zone of *Pecten asper*, as well as of higher Cretaceous beds	about 20
Zone of *Schloenbachia rostrata* (Sowerby).	3. Yellowish-brown sand (Foxmould)	60–80
	2. Yellow sand containing three layers of indurated nodules (Cowstones)	30–50
Zone of *Hoplites interruptus* (Bruguière).	1. Black and dark green loams	20

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[1] For a short account of these biological groups see Henslow, *Natural Science*, vol. xv (1899).

[2] Seward: "Fossil Plants," vol. i, chapter v.

[3] Buckman: ibid., p. 232.

The fossil-bed here described was first found by the author in April, 1901, and fossils from it have been obtained on several subsequent occasions.

So far as can be determined the bed has not yet been described, though it may have been mentioned by Mr. A. J. Jukes-Browne in dealing with the Gault and Upper Greensand of England.[1] He speaks of "the highest visible bed" at Black Ven as being composed of "brownish sand with green grains and many broken shells of *Pecten* (*Neithea*) *quadricostata*, recalling sand seen at Foxton, near Chard." Further than this he does not describe it, and I am inclined to think that he refers to a bed at the top of the cliff, immediately under the Golf Links, about half a mile further westwards. Otherwise he could not have failed to mention the number of other fossils, notably *Exogyræ*, with which the *Neithea* fragments are associated.

Mention is also made in the same place of "a nest of silicified but fragmentary fossils, ... resembling very poor Blackdown specimens," found by the Rev. W. Downes in 1884.[2] But on referring to Mr. Downes' paper it seems that the fossils he found were at least a quarter of a mile further west; for he describes them as occurring "50 feet above the spot in the Gault where I obtained the other fossils, and in nearly a straight vertical line above it." Tracing this line from where Gault fossils are *now* exposed, we reach a locality where there is no section, although cliffs are present on either side of this spot, the junction of the old and present Lyme roads. As the present road had only been made four years previously to Mr. Downes' paper, it is probable that these cliffs were then much less overgrown, and possibly his fossil-bed is the same as that described below, appearing further westwards, which (if there) is now hidden by overgrowth and talus. Even so, it will be seen by the section following that the latter is considerably more than 50 feet above the black Gault loams.

At a height of from 370 to 400 feet the road at present used between Charmouth and Lyme has been made for some distance along the face of the cliff, passing along the lower part of the zone of *Schloenbachia rostrata* (Sowerby), which consists of yellow sands locally called 'Foxmould.' This Foxmould forms a cliff of varying height overhanging the roadway, and at a spot situated some one and a half miles from Lyme Church, and about half a mile from Charmouth Church there is a small cliff on the seaward side of the road. This cutting is called by the villagers the 'Devil's Bellows,' on account of the great force with which a gale blows through it, facing as it does the south-west. The inland cliff is 75 feet in height, and the main fossil-bed occurs at a height of about 50 feet.

The following section, measured in September, 1902, gives a general idea of the beds of which the Foxmould consists. The small divisions, however, probably thin out rapidly in all directions, and so are of no use in correlating the beds from hill-top to hill-top.

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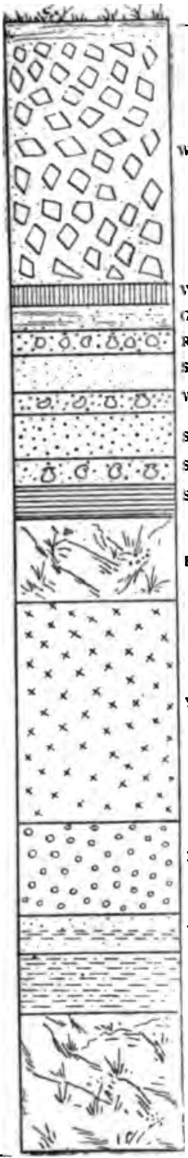
[1] A. J. Jukes-Browne: "The Gault and Upper Greensand of England," 1900, p. 186.

[2] W. Downes, "The Cretaceous Beds at Black Ven, near Lyme Regis": Quart. Journ. Geol. Soc., vol. xli (1885), p. 23.

SECTION AT THE CUTTING, CHARMOUTH.

Scale, 1 foot = ·076 inch.



Feet above sea-level. ft. ins.		Bed	ft. ins.
450 0	Weathered remains of Chert beds, i.e. lower half of zone of *Pecten asper*, consisting of angular Chert fragments, in a sandy matrix		20 0
431 0	Very dark green, loamy, glauconitic sand, veined with purplish-black and pink-red iron oxide	12	0 5
	Greenish-brown glauconitic sand, with occasional veins of purplish-black iron oxide, and occasional obscure fossil remains	11	0 15
429 0	Reddish and brown glauconitic sand, crowded with fragmentary shells, chiefly *Exogyra* and *Neithea*, and bits of Chert	10	0 6-8
426 6	Same as bed 11. Greenish-brown glauconitic sand, with occasional veins of purplish-black iron oxide, and occasional obscure fossil remains ..	9	2 6
425 8	Whitish and yellow glauconitic sand, with fragmentary shells in Beekite, and casts in purple-black iron oxide, and specks of purple-black iron oxide	8	0 10
	Same as bed 8, with no or few fossils	7	3 0
422 8 421 0	Same as beds 8 and 9, with many fossils in Beekite, and casts in purple-black iron oxide	6	1 8
419 0	Salmon-pink and white glauconitic sand, with flecks of purplish-black iron oxide	5	2 0 sh
413 0	Broken ground		6 0
396 2	Yellow and white glauconitic sand with occasional obscure fossil remains, and a little iron oxide	4	17 0
389 8	Darker yellow and white glauconitic sand, with occasional obscure fossil remains	3	6 6
387 0	Yellow and white glauconitic sand veined with black clay	2	2 8
383 0	Reddish-yellow glauconitic sand	1	4 0 s
373 0	Broken ground		10 0

West. ☚ Roadway—Charmouth to Lyme. ☛ *East.*

☚ To Lyme 1½ miles. To Charmouth ¾ mile. ☛

It will be seen that there is a gap of 6 feet in the middle of the section where no sand is exposed, the cliff being here obscured and overgrown with grass, gorse, and broom.

Of the three beds in which fossils occur, the uppermost (No. 10) is by far the most productive, the lower two beds (Nos. 6 and 8) yielding chiefly *Exogyræ*; moreover, these are not so well preserved as those in the highest bed.

The fossils obtained from the bed (No. 10) are as follows. The numbers after the names indicate the number of specimens found :—

MOLLUSCA LAMELLIBRANCHIATA.

Alectryonia frons (Parkinson), 2.
? *Anomia* sp., 1.
Avicula sp., 1.
Exogyra canaliculata (Sowerby), 1.
Exogyra conica (Sowerby), abundant.
Exogyra plicata (Lamarck), 2.
Ostræa sp., 1.
? *Pecten* (*Syncyclonema*) *orbicularis*, Sowerby, 1.
Pecten (*Neithea*) *quadricostata*, Sowerby, abundant.
Septifer lineatus (Sowerby), 1.

MOLLUSCA GASTEROPODA.

Turbo sp., 1.

ANNELIDA.

Serpula ilium, Sowerby, 2.
Serpula filiformis, Sowerby, 2.

ECHINODERMATA.

One Urchin spine.

BRYOZOA.

Cellulipora ornata, D'Orbigny, var. *devonica*, Gregory, 1.
Entalophora sp., 1.
Entalophora (?), 1.
Ceriopora (?), 1.

The following is a list of the fossils found by Mr. Downes[1] :—

MOLLUSCA LAMELLIBRANCHIATA.

Cardium proboscideum, Sowerby, 3 small fragments.
Cucullæa fibrosa, Sowerby, 1.
Cucullæa glabra, Sowerby, 4.
Cyprina cuneata (Sowerby), abundant.
Cytherea caperata (Sowerby), 4.
Gervillia rostrata (Sowerby), abundant.
Exogyra, 1.
? *Pecten orbicularis*, Sowerby, 1.
Pecten quinquecostatus, Sowerby, fragment.
Trigonia scabricola, Lycett, 2.

MOLLUSCA GASTEROPODA.

? *Phasianella* sp., 1.
Turritella granulata, Sowerby, 1.

ANNELIDA.

Serpula sp.

PORIFERA.

? *Siphonia*.

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[1] Downes, ibid., p. 25.

The *Pecten quadricostatus*, Sowerby, and the *Exogyræ* are by far the commonest shells, the Pectens being mostly fragmentary; but I have found nearly perfect ones, which, however, have invariably fallen to pieces on being removed.

All the fossils are siliceous, many, especially the flat fragments of *Pecten*, showing the curious concentric structure peculiar to Beekite.

The obscure fossil remains in beds 3 and 4 are casts in sand, which at once fall to pieces on removal; but none of those found could be identified. Possibly they are the 'impressions' mentioned in the Survey Memoir.[1]

Half a mile further westwards, where the Foxmould cliff recedes some two hundred yards from the road, and immediately beneath the Golf Links, another fossil-bed occurs. This, like the last, lies within a foot of the capping of chert detritus, but is at a higher level, the cliff rising here to about 500 feet. This has yielded fragments of *P. quadricostatus*, Sowerby, and from it in September, 1902, I obtained some fine specimens of *Exogyra conica*, Sowerby.

My best thanks are due to Dr. F. L. Kitchin and Mr. E. T. Newton, F.R.S., of the Museum of Practical Geology, for their kindness in helping me to identify the specimens.

III.—SOME DISPUTED POINTS IN THE CRYSTALLISATION OF THE CONSTITUENT MINERALS OF GRANITE.

By A. R. HUNT, M.A., F.G.S.

IN writing my little paper on vein-quartz I was particularly anxious not to introduce controversial matter, but to be strictly orthodox throughout. After the paper was published I was much perturbed to find that I had unwittingly come into collision with two incidental remarks in General McMahon's most interesting paper on the Satlej granite, which was the subject of his address to Section C at Belfast. My oversight arose owing to the said remarks being incidental, and no stress having been laid upon their paramount importance.

To explain, the modern theory of granite is a chemico-physical one, founded on the critical temperatures of carbonic acid and of water. According to the physical evidence, ordinary granites crystallised about the critical temperature of water; some minerals possibly above, and others below; or all above, or all below. The critical temperature of water I have taken as 342° C. (Rep. Brit. Assoc., 1877, p. 236). The chief witnesses are the various inclusions of gas, water, and other liquids, and the deposited crystals contained in the water inclusions.

In my paper I assumed it to be an accepted fact that deposited crystals were proof positive that the mineral containing them was crystallised below the critical temperature of water, and that groups of inclusions with proportional amounts of carbonic acid and water were evidence of a temperature above the critical temperature of water. I also assumed that above the critical temperature of water,

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[1] Jukes-Browne: ibid., p. 186.

water could not exist as a liquid, whatever the pressure; for that, as I understand it, is the meaning of the term critical temperature, or critical point.

Now, on carefully studying General McMahon's paper, I find that, after deducing an approximate temperature of the Satlej magma from the fusion temperatures of the individual minerals, of which he tells us beryl was the first to crystallise, at a temperature approaching 1,200° C., he further tells us that the beryl contains water inclusions with deposited crystals, and gas inclusions. The General further describes water as being held by pressure in a liquid state, in the more than red-hot magma.

These statements are not only inconsistent with the old physical theory of granite, but entirely subversive of it. On reviewing my paper in the light of General McMahon's address, I found that the question at issue could be indirectly reduced to a single point, which involved (if a point which has no magnitude can be said to involve) all the others. That point is the correctness or otherwise of Professor Hartley's conclusions as to the crystallisation of topaz. I thought it the better plan to refer the question at once to Professor Hartley, and enquire whether in the last twenty-five years he had seen any reason for reconsidering his conclusions as to topaz. If the answer were in the affirmative I would withdraw my paper without reserve. But Professor Hartley has been good enough to reply to my enquiry, and the answer is in the negative. Thus I find myself once more in the hopeless situation of the crook between the pot and the kettle.

Many of the readers of the Magazine must, I am sure, be golfers, and I am confident I may rely on their sympathy as being the mere captain of a golf club with a couple of antiquated microscopes, and far more competent to write an article on mashie approaches and putting than on the consolidation of granitic minerals. They will also agree that mashie approaches are far more important than fluid inclusions.

The case, however, is simple, and the evidence perhaps more easily tested by the ancient microscopes than by the cheaper and more popular modern ones, which often dispense with special sub-stage apparatus and mechanical stage. All my petrological readers, with a fair collection of slides, will have among their specimens slices containing liquid carbonic acid. If the subject is new to them, I would suggest their reading Dr. Sorby's and Professor Hartley's remarks on liquid carbonic acid, and having done so to treat these eminent scientists at the outset with respectful scepticism. There is no reason to blindly accept their testimony, because it is open to any petrologist to put much of it to the proof for himself; and it is always safe to follow the example of the late William Froude, F.R.S., who once described himself as a first-rate doubter. Now what we gather from Messrs. Sorby and Hartley is, that in numerous minerals inclusions occur containing two fluids, and that on heating the specimens one fluid often disappears at or about the critical temperature of carbonic acid. In fact, one of the fluids behaves exactly as carbonic acid should do. I am indebted to Mr. C. W. Priestley, F.C.S., for information as to the latest determinations of the critical temperature of CO_2 and of its pressure at the critical temperature. The critical temperature is 87·75° F., and the pressure 77 atmospheres or 1,155 pounds to the square inch. In the case of the larger cavities Professor Hartley describes the strain on the including crystal as visible in the polariscope. The first experiment, viz. that as to the disappearance, is readily made. We take an inclusion with water and CO_2, and mark the position of the slide on the microscope stage so that we can easily replace it. We warm the slide over the microscope lamp and replace it. The double liquids are gone. The carbonic acid, as gas, is apparently dissolved in the water; but, while we watch, the carbonic acid often returns with a jump. The suddenness with which the carbonic acid often reappears shows that the passage from above to below the critical temperature is very closely defined. It is not a question of the absorption by the water of a little more or less gas. We find further that chemists have experimented largely with various liquids and gases as to critical temperatures, so that the general principle of critical temperatures is well understood.

So far as I can follow the observations of Messrs. Sorby and Hartley on carbonic acid, I find them correct; so I am favourably disposed towards their interpretation of the behaviour of water, and to believe that a liquid alone is competent to dissolve and deposit free salts. This view is indirectly confirmed by the fact that volcanoes discharge hydrochloric acid and chlorine, substances which Dana attributes to the dissociation of marine chlorides which have obtained access to the lava column. If, however, the chlorides of sodium and potassium are dissociated more or less into their elements at volcanic temperatures, say, into hydrogen, chlorine, and soda or potash, and if these substances are then individually dispersed throughout the liquid lava, it would require a miracle for them all to come together again, to be dissolved by water as chlorides, and then deposited as solid crystals in the various minerals which occasionally contain them. It would require a miracle even were the substances retained in the lava, but, according to Dana, volcanoes get rid of both the gases concerned, both as hydrochloric acid and separately as hydrogen and as chlorine.

If, however, anyone can prove the existence of chlorides which have been deposited above the critical temperature of water, we, with all adverse theories, must bow to the fact and accept the miracle. But, when we examine General McMahon's facts, we find them all in favour of the orthodox doctrine. Upon the beryl, containing gas, and fluid inclusions with deposited crystals (species not mentioned), we find crystallised the minerals quartz and muscovite, both of which minerals occur in schists and other non-igneous rocks. Although the dry-fusion temperatures of quartz and muscovite are high, their wet crystallising temperatures may be quite low. Indeed, they must sometimes be so or they would not occur where they do. Fouqué and Lévy mention the crystallisation of quartz at a temperature of 200° C. Being, however, an undoubted crock, I am extremely disinclined to come between the geological pots and the chemical kettles; and I need only say that my sympathies are with the chemical kettles, because they seem to me to account for all the phenomena which I have observed with my antiquated microscopes.

It has always been a very great perplexity to me that, whereas I have ever relied on the evidence of the critical temperatures, the fluid inclusions, and the deposited chlorides, the great geological authorities, to whom, as captain of a golf club, I bow with genuine humility, scarcely ever refer to or notice these things; and, in consequence, I am in eternal uncertainty. The question always arises, have the geologists disproved and rejected the physical evidence, or do they only ignore it?

Not very long ago two eminent men disputed over the relative fusion temperatures of granite and basalt; but surely the question really is as to the relative crystallising temperatures of these rocks; and, as we know for a fact that basalt can be artificially produced by dry fusion without the intervention of water, and as we also know that granite almost invariably contains water in one or more of its minerals, the dry-fusion temperatures of the two rocks become a mere academic question. Is this not so?

The main wrangle is as to what becomes of the water-vapour above the critical temperature. Well, being a gas it may well be dissolved in the liquid magma, and there it may stop until the lowering of the temperature allows it to resume its liquid state, when it will begin to dissolve the minerals instead of being itself dissolved; but, seeing the rarity of chlorides as rock-forming minerals, it seems improbable that there would be much chlorine or hydrogen in the magma at the cooling stages to enter into combination with the metals, especially as we know for a fact, as has been already noticed, that both those gases are got rid of by volcanoes. The suggestion of Dana that the volcanic hydrogen arises from the dissociation of water is rather negatived by the fact that, while volumes of steam are emitted by volcanoes, hydrogen only occurs in small quantity, and is therefore more likely to be due to the dissociation first of the chlorides and then of the hydrochloric acid, HCl. Were the water itself dissociated, we might expect volcanic flames on a magnificent scale if the hydrogen recombined in the atmosphere, or constant explosions if the hydrogen recombined in the lava column. As a matter of fact, volcanoes often emit steam very quietly.

Petrologists are much more interested in the proportions of potash, soda, and lime in a felspar, and the consequent angle of extinction of the crystal, than in its crystallising temperature. Yet the crystallising temperatures of the same felspar often vary exceedingly. For instance, General McMahon in his address spoke of the fusing temperature of albite as 1,172° C. Subsequently, when I read my paper, I exhibited a lantern slide showing secondary albite in one of the Devonshire green-schists, which albite contains water inclusions and chlorite, and is associated with other hydrous minerals. Then, as to quartz: in a slightly altered Devonshire diabase we find, besides chlorite in abundance, secondary quartz-granules which contain fluid inclusions and deposited crystals. No one would attribute much heat to these rocks at the time of alteration; and, as for the diabase, its accompanying Devonian slates do not even reach the dignity of phyllites. Then, on Dartmoor we find felspar, quartz, and tourmaline crystallising at temperatures too low to produce a granitic structure. Although the rule there, is, that the felspar crystallises before the quartz and greenish tourmaline, I have detected one case in which, after the breaking down and partial solution of a felspar by quartz-liquor containing tourmaline-belonites, the felspar repaired damages at the cost of the quartz, and enclosed some of the belonites. This might possibly be explained by the process of cooling being checked, and by a slight reheating first dissolving the felspar and then permitting the recrystallisation of that mineral. But felspar, quartz, and tourmaline were clearly in this case crystallising in the wet way. Dry-fusion temperatures would not assist us in the least; indeed, they could only mislead.

With regard to the permeability of rocks, although, as we have seen, many minerals in mass will resist the pressure of a gas at 1,155 pounds to the square inch for countless ages, and in the thinnest section for an indefinite time, the same minerals are liable to minute and successive fractures; so that a series of water inclusions may traverse a plane of water and carbonic acid inclusions. Although the fluids were originally introduced through planes of fracture, the mineral may be so completely restored that no evidence may remain of the original fissures. In one specimen water inclusions, carbonic acid inclusions, and inclusions with deposited crystals occur near together. It is obvious on inspection that the carbonic acid inclusions are later than the crystal, and that the water inclusions are later again. The relative age of the inclusions with deposited crystals is not apparently indicated. The great charm of the physical theory of granite is that it affords possible solutions for many enigmas, such, for instance, as that of augite-granite, where we find a true high-temperature mineral associated with those of low temperature.

Just at present tourmaline is exercising the minds of petrologists. Nearly forty years ago I took some lessons in mineralogy from Mr. Tennant in the Strand, and I learned that tourmaline had no cleavage, but only a pseudo-cleavage. In after years the absence of tourmaline proved to be the great test of the non-Dartmoor origin of the blocks trawled in the English Channel. Later still I bought a Dartmoor farm, where I can never step outside the door without trampling under foot the tourmaline 'waterstones,' or river stones, which pave the garden path. Many years ago Professor Bonney was good enough to give me his paper on Luxullianite, wherein he derives tourmaline from mica and felspar. I hunted Dartmoor for some years in vain for any evidence that the Dartmoor tourmaline was derived directly from either of those minerals, came to the conclusion that Cornish tourmaline must be q different from Devonshire tourmaline. In trying to work Mr. Jukes-Browne's sands I found it absolutely necessary to co to some conclusion as to the mica-derivation theory, and as Mr. Jukes-Browne to go through my slides with me, as my i was that the mica-derivation was not in evidence on Dartm whatever it might be elsewhere.[1] To my great amusement delight I have since read Mr. Scrivenor's paper, wherein he deri the Cligga Head brown tourmalines entirely from mica; so o more the luckless crock gets among the pots. It is really a n interesting question. As tourmaline is an aluminous mineral which boracic acid is an essential constituent, there seems no rea why, with the advent of boracic acid, tourmaline should not constructed out of any mineral that will supply the other c stituents, such as mica, felspar, slate, or clay. But as tourma occurs on a large scale as massive schorl-rock, and as in Devon Cornwall mica occurs comparatively sparingly as scattered isolated crystals, and, further, as the crystals of tourmaline are o large and those of mica always small, the amount and size of mica seem unequal to the task of supplying the bulk of tourmaline, at any rate as it occurs in Devonshire.

For all practical purposes Devonshire tourmaline occurs as th distinct minerals, viz., idiomorphic with the characteristic tra verse pseudo-cleavage, in fan-like bundles, and in needles and r The characteristic microscopic idiomorphic crystals are apt to sh a very marked longitudinal cleavage, which is entirely contr to 'Cocker.' A longitudinal splinter of tourmaline might be l a flake of mica, but here the vertical *versus* the horizontal extinct would distinguish the two. A transverse splinter of tourmal would appear to extinguish horizontally, but would differ fr mica in the pseudo-cleavage not being absolutely straight. T passage of mica into tourmaline would be an interesting process trace, as the horizontal extinction would have to change i a vertical extinction.

In his recent paper Mr. Scrivenor has the following passages, viz.

(1) "In discussing the origin of the brown tourmaline Luxullianite, Professor Bonney suggested that that mineral n have been derived from the biotite of the granite; . . . .

(2) "The inferences which I have drawn from the study these slides is that all the brown tourmaline has been formed fr the biotite; . . . .

(3) "Professor Bonney suggested that the blue tourmaline Luxullianite has been derived from the orthoclase; . . . ."

In my own slide, besides the innumerable greenish acicu crystals, there is one compact crystal, of which one half is li cobalt blue and the other half light brown. It is absolut characteristic in its transverse pseudo-cleavage, and I wo willingly stake my reputation as a golfer that this crystal has not the most distant connection with mica. So far as I have been able to judge from the few sections I have seen, the Cornish granites differ from the Dartmoor granites. In Cornwall there seem to be more pressure and fewer chlorides in the main granites. I have noticed bent mica, which is a very significant clue. My Cornish elvan-slides, too, are not so simple as those from Dartmoor; there is more evidence of re-solution. Thus it is quite likely that a good many things occurred to the Cornish granites which did not happen to the more simple and less metalliferous Devonshire rock, and it may not be safe to judge the one by the other. I gather, for instance, that the schorl-veins in Cornwall are sometimes micaceous. Those on the east of Dartmoor seem never to be so. I have a specimen of tourmaline granite sharply in contact with and invading a micaceous granite, in which the tourmalines in the one and the micas in the other, closely adjacent, are absolutely characteristic, and keep strictly to their own rocks.

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[1] Derivation from felspar I have since then occasionally noticed; but my sl do not seem to contain an indisputable case of derivation from mica.

As a very rough working hypothesis I would suggest the following explanation of the eastern elvans and non-granitoid felspar-quartz-tourmaline veins. We must assume the previous cooling of the main granite, because both elvans and non-granitoid veins invade it. The elvans have the true granitic structure, the non-granitoid veins have not; so we take the elvans to represent a hotter stage of the intruding minerals. These elvan intrusions, whether in the granite or in intrusions a quarter of an inch wide in the Culm slates, contain characteristic idiomorphic crystals of tourmaline, which have crystallised first; and the veins, both granitic and non-granitoid, usually contain no trace of mica. When we get down to the non-granitoid veins, in which the felspar, tourmaline, and quartz have crystallised in succession, we find the tourmaline often to be the fan-like variety, while occasional compact crystals are not specifically characteristic, as they have no transverse pseudo-cleavage. The crystals here seem by nature gregarious, whereas in the granitic veins they are characteristically solitary. In the non-granitoid veins we have proof that the tourmaline occasionally crystallises after the quartz; in the granitic veins never.

If there is any truth in the doctrine of critical temperatures, there is no shadow of a doubt that the non-granitoid veins crystallised out of liquid, below the critical temperature of water. The highest temperature of the elvan-veins is not so certain, but their quartzes almost invariably prove that the rock had cooled down below the critical temperature of water before they, the last mineral in those rocks, crystallised. We have this apparent anomaly, viz., that in the granitic elvan-veins the tourmaline was the first mineral to crystallise, whereas in the non-granitoid veins the tourmaline occasionally crystallises after some of the quartz. But these two tourmalines differ so much in character that no one would guess they were the same mineral unless credibly so informed. Between these extremes of tourmalines there are many intermediate stages.

According to the evidence all these tourmalines crystallised *de novo* out of a magma or liquor derived from the solution of the older granite by fluids charged with boron and possibly fluorine, though fluorine is not much in evidence on the eastern side of Dartmoor, which may indeed account for the greater simplicity of the rock. This solution of the rock and recrystallisation of its minerals was suggested by De la Beche, but in my ignorance of that fact it was forced upon me independently.[1]

The narrow granitic intrusions in the Culm grits afford excellent opportunities for observing the effect of the invading liquor on the two sides of the fissure, and we may see that the aluminous interstices between the sedimentary quartz-granules are sometimes tourmalinised and the quartzes occasionally dissolved; but, for some not obvious reason, the fluid inclusions in my slides stop short at the granite. If tourmaline were a hydrous mineral this might be expected. Is it possible that the water is taken up by hydrous iron-oxide? This tourmalinisation of the alumina of the grits affords the key to a large group of schorlaceous and altered grits, and shows us how tourmaline may either be crystallised out of a liquor containing all the needful constituents or in clays or felspars which supply the alumina *in situ*. Tourmaline, we see, is not only an extremely variable mineral in colour, form, composition, and mode of aggregation, but is also a mineral formed under very variable conditions of heat and, possibly, pressure. If thoroughly worked out, each variety of tourmaline would probably not only explain itself but also the minerals with which it is associated.

We have heard much lately from Professor Frankland,[2] Mr. Wells,[3] and others, of the effeteness of our old universities, and of Trinity College, Cambridge, in particular. I fear the charge is true. They have not elucidated tourmaline. Yet there have been among their graduates painstaking students, such as Bonney, Hughes, Teall, Tawney, Harker, Hill, Marr, Sollas, Jukes-Browne, and many others. Trinity College is scarcely responsible for myself, because, although I presented myself for examination more than forty years ago, with a more than average schoolboy knowledge of the works of Page, Yarrell, and Westwood, on geology, ornithology, and entomology, and in the way of mechanics had made more than one steam engine, the College earned my lifelong gratitude by 'plucking' me in classics and giving me a much needed lesson in accuracy. I would not exchange that 'pluck' for a doctor's degree; and very thankful I am too that pass degrees in science were not then obtainable.

Pace Messrs. Frankland and Wells, I admit to being one of those wretched beings who much prefer the golf-links to the laboratory; and, indeed, nearly all my attempts at natural history (which pursuit has little in common with the modern commercial and remunerative idea of science) have been made sandwiched with shooting, yachting, farming, and even golfing. If, indeed, a new era has now arisen,

[1] Geol. Rep. on Devon and Corwall, p. 387.

[2] Rep. Brit. Assoc., 1900, p. 593 et seq.

[3] "Anticipations," p. 368.

with improved universities, and improved students with keener perceptions of Nature's minute differences, the old stagers will no doubt welcome them gladly. The British Association meets at Cambridge in 1904, with a Trinity College golfer as President, an ex-captain of the "Royal and Ancient," so here is a chance for the new learning, to elucidate tourmaline and shame the effete.

Personally this granite problem has worried me beyond all reason. For some years I absented myself from the meetings of the British Association and Geological Society, determining not to go to the former until I could attend as an outsider and accept in silence any view whatsoever, and not to go to the latter at all. In 1900 I thought I had attained this state of geological grace, and went to Bradford, where I looked forward to hearing an interesting volcanic debate in luxurious indifference. Now it so happened that when the petrological papers came on, the President and most of the Vice-Presidents had to attend the Committee of Recommendations, while the Vice-President in the chair happened to be a distinguished President of the Geologists Association, to which society the Torquay naturalists had been privileged to show a little attention. No doubt by way of a very pretty compliment to the Torquay Society, and as I happened to be one of the oldest members of committee present, I was requested to take the chair on the spur of the moment, and even after one of the papers had already been read, with instructions to foster a good discussion for a distinguished foreign petrologist. That, with the tact of the Recorder, was easily managed. I was, however, in an extraordinarily false position, as I knew absolutely nothing of the special points under discussion, but I noticed that the old physical theory of granite was ignored by everyone. By way of returning the compliment I submitted a little paper at Belfast which I intended to confirm and elucidate the doctrine I supposed to be orthodox; and lastly, I wrote my short paper on vein-quartz to the Magazine with the view of indicating to students a fruitful subject of enquiry on strictly orthodox lines. I want it to be distinctly understood that I am not writing the present paper as an ex-chairman of Section C and a smatterer in petrology, attempting to teach my betters; but that I am writing as an outside observer, a unit in the crowd of uneducated Englishmen styled by Mr. Wells the "Grey" and the "Abyss," a member of that university and college which modern scientists affect to despise, a naturalist "by grace of the dredge," that abomination of Huxley, and last, but not least, the captain of a golf club. As such I would, in the spirit of friendly expostulation, point out to petrologists how desperately they are puzzling the average Englishman.

Let us face the matter squarely. In the first half of the last century De la Beche expounded the problem of the Western granites macroscopically, with almost unerring precision and prophetic insight. In the early years of the second half of the century Dr. Sorby created the subject of micropetrology with his epoch-making researches on fluid inclusions in their various aspects. His paper of 1858 was an astounding one, but surely one must not blame it if not final and exhaustive! Dr. Sorby attempted to deduce the weight of once superincumbent strata from the uniformity of the fluid inclusions. It was, however, soon noticed that fluid inclusions are often not uniform. Petrologists at once ran off with the idea that Dr. Sorby's theory had collapsed. Dr. Sorby, however, accepting the teaching of the variable inclusions, pointed out that variable inclusions indicated varying conditions during crystallisation, a fact infinitely more important than the deduction that uniform fluid inclusions might supply a tape measure for measuring the thickness of strata. If we are to credit chemists and physicists, Dr. Sorby is correct in his premisses, and these premisses go to prove that at any rate the final consolidation of most granites was at a temperature below the critical temperature of water; and this critical temperature is as important a mark for the petrologist on the physical thermometer as that of blood heat is to the doctor in his clinical thermometer. Now what would the world say if, knowing as the world does the value of the clinical thermometer, the whole medical profession were to discard it without so much as discussion? Yet this is precisely what the petrological profession has done with its own physical thermometer. And it has done it in the most authoritative way. For many years past petrologists have been quietly treating granite as a high-temperature rock. They have even tacitly accepted Lord Kelvin's theory that granite was the rock primæval, whose minerals crystallised out of and gravitated through a basalt lava. They now accept without demur the doctrine that quartzes, containing both gases and fluids with deposited crystals, can have crystallised at high volcanic temperatures. Well, be it so, but they must not expect golfers and the rest of the uneducated public to follow them, simply because the geological doctrines are self-destructive. Otherwise the said public would have no right to form an independent opinion.

With regard to the origin of plutonic rocks, what we want done is to satisfy both chemists and geologists. For instance, the geologists say that crystals are permeable. The chemists declare that at any rate many crystals will withstand gas pressure of 1,155 pounds to the square inch for geological epochs. I have one set of carbonic acid inclusions which have been imprisoned since Devonian times, yet they will in a thin section undertake their 1,155 lbs. pressure as often as desired. The geologists say that crystals of chlorides can be deposited by water or water-vapour at a temperature approaching 1,200° C. The chemists say "Tush!" or think so.

Here is an important fact. Professor Hartley tells us that when carbonic acid inclusions are present, it is easy to ascertain the temperature of crystallisation of the enclosing mineral.[1] He observes incidentally that such inclusions occur in tourmaline,[2] but as tourmaline is not in the line of his enquiry he omits to state the crystallising temperature of tourmaline; yet that is one of the geological desiderata.

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[1] Rep. Brit. Assoc., 1877, p. 236.

[2] Loc. cit., p. 233.

The reason I am anxious to press this question of critical temperatures on geologists is, that I feel sure that the majority do not realise the value or perhaps even the existence of the chemical evidence. Professor Hartley has pointed out that the very variation from the true critical temperature of CO_2 observed in a microscopic inclusion may suffice to indicate the foreign substance mixed with the CO_2, such as nitrogen or hydrochloric acid.[1] It is clearly of great importance if the mere magnifying microscope can tell us the gases, fluids, and solids caught up by a crystal, and the temperature of crystallisation. But petrologists obviously either doubt the value of the evidence or are ignorant of it, for students have ere now been rebuked in the most serious and public manner, not for misapplication of the evidence, but for treating it as worthy of credit, while their teachers treat it as though non-existent. I would not ask petrologists to look to this matter if I were able to do so for them. Friends have wished me to make the attempt, but the idea is too ridiculously absurd. The subject involves a profound knowledge of both chemical physics and optical petrology, and I have neither, nor the power to acquire it. When I go into a golf club I have no occasion to ask any individual member how he plays. The club decides that point for him. I look at the list of handicaps, and see at once whether he is an honour man or a poll man. The universities give men their intellectual handicaps, and in the case of diligent workers the university decision is rarely wrong. My own university handicap was one which Huxley would have deemed scarcely fit even for a bishop, as he allowed even bishops first-class polls. But even indifferent golf-players are allowed to enter competitions, which they do with the more than acquiescence of their superiors, who give them points, *alias* assistance. Since writing this paper I have been impressed with the analogy between the competitions of science and golf. I had to play in a final competition for medallists for a £5 prize, so secured a better player to play me a match and score for me. As a match between ourselves I was successful, with an erratic round including nine fours; but my whole round, or theory, irretrievably broke down at one hole, which cost me thirteen strokes, instead of the orthodox five. Composite science is like medal play at golf. Erratic brilliance is useless; one fatal flaw in either round or theory is as bad as general incompetence. Now the problem of the plutonic rocks and minerals may be compared to a golf course with many and varied holes. We have physics, optics, chemistry, mineralogy, stratigraphy, and general geology. When our cards are examined at the close of the competition, it will be ascertained whether each difficulty has been individually surmounted. If we pick up our ball at either hole, or are guilty of any breach of the laws of golf, we are fatally disqualified, and notwithstanding phenomenal brilliance at our favourite holes, our medal round, our theory, is of less value than the card on which it is scored, as that may serve to light a cigarette. Perhaps the chief difference between golfers and scientists is that golfers always know when they are 'bunkered,' whereas scientists apparently are often unconscious of the fact, and think nothing of teeing their ball in a hazard. A hazard in plain English is a difficulty, which, according to the laws of golf, if encountered must be surmounted, and not evaded. Evasion, if detected, involves disqualification; but gentlemen do not evade.

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[1] "On Variation in the Critical Point of Carbon Dioxide in Minerals," etc.: Journal Chemical Society, 1876. Reprint, p. 12.

With respect to the general question of the crystallisation of rocks we have this curious paradox, viz., that after a rock had consolidated, and already cooled considerably, at a dry heat, the mere advent of water would liquefy it. This, besides being in evidence, follows from the fact that so many minerals which crystallise at high temperatures in the dry way crystallise at low ones in the wet way. Many of the old geologists took the possibility of the access of water as granted, but subsequently this was stoutly denied. However, after the blow up of Krakatoa and of the hot-lake district in New Zealand, the evidence seems to favour the ancients. Considering that many regions are jointed and fissured in all directions, and that earthquakes make fresh fissures, and seeing that a column of water at a depth of 3,000 fathoms weighs about 600 atmospheres, or 9,000 pounds to the square inch, the access of water to highly heated though consolidated rocks seems more probable than otherwise. But if such access ever occurs there must be liquefaction, reconstruction, recrystallisation, and metamorphosis in almost every variety; and the creation of new minerals too, for the sea-water does not come empty-handed, but charged with the highly important rock-forming minerals soda, potash, magnesia, and lime. But when we come to chemistry at a pressure of 600 atmospheres and upward, we cannot safely afford to ignore the chemists and the physicists, any more than physicists can afford to formulate a theory of granite in defiance of petrologists, as was actually done a few years ago.

I would desire, very respectfully, to point out the great perplexity caused to students by what may be termed incidental petrology. The whole object of the present paper is to discuss General McMahon's incidental remark—"the beryl is crowded with liquid and gas cavities, the former containing movable bubbles and deposited crystals as well as water" (Rep. Brit. Assoc., 1902, p. 590).

So far as I am aware, the only record of the occurrence of magnetite in cubes in Great Britain is Professor Bonney's quite incidental statement—"Magnetite, very abundant in minute grains, which, however, evidently are often cubes or octahedra" (Proc. Roy. Soc., 1892, p. 399). As has been already pointed out, the extremely important question of the derivation of tourmaline was discussed, also quite incidentally, in a mineralogical paper dealing with Luxullianite.

Lord Kelvin's theory of granite and basalt, again, was completely incidental to his "Age of the earth." It is, no doubt, incompatible with all previous doctrine on the subject, but with the general public, on this as on every other subject, Lord Kelvin's judgment is law. Weighed in the public scales, Lord Kelvin will pull down every geologist, past, present, and to come.

I have not the smallest ambition, in the matter of granite or in any other, to convert geologists to my own way of thinking. I only seek information in order that my own way of thinking may be corrected if erroneous.

IV.—NOTE ON A SECTION OF GREAT OOLITE BEDS AT CONDICOTE, NEAR STOW-ON-THE-WOLD.

By L. RICHARDSON, F.G.S.

ONE mile north-west by west of Condicote in the North Cotteswolds, a village distant about 2¾ miles in the same direction from Stow-on-the-Wold, there is a quarry in which the following beds are exposed:—

SECTION NEAR CONDICOTE.

		ft.	in.
1.	Dark-coloured soil	1	4
2.	Yellowish, clayey marl, with a little rubble of whitish and slightly oolitic limestone in places near the top; *Rhynchonella concinna*, *Terebratula maxillata*, *Ataphrus Labadyei*, *Cerithium* (smooth species), *Nerinæa* cf. *Dufrenoyi*, D'Arch., *N.* cf. *Voltzi*, Desl., *Chemnitzia* cf. *hamptonensis*, M. & L., *Isastræa limitata* with specimens of *Ostrea* adhering to it, *Microsolena* (probably *M. porosa*, Lam.), *Modiola Lonsdalei*, *Trigonia pullus*, *Ostrea Sowerbyi*	1	11
3.	Grey, somewhat arenaceous, flaggy limestone; *Ostrea* aff. *acuminata* ...	6	0

Reference to the Geological Survey map, Sheet 44, will show the exact position of the quarry: to the south of the junction of the road from Condicote to Scarborough with that leaving the main road opposite the lane which comes past Rook Pool Barn (now Kinetonhill Farm) and Rook Pool. The area in which the quarry is situated is thus indicated as being composed of Inferior Oolite rocks. The fauna contained in Bed 2, and especially the *Rhynchonella* and *Terebratula*, clearly shows that this is an error. I am indebted to Mr. W. H. Hudleston, F.R.S., for kindly examining the Gasteropods. Their state of preservation only allowed of their being identified approximately, but, as Mr. Hudleston observed, "they certainly wear a Bathonian facies rather than that associated with the Inferior Oolite."[1] Mr. R. F. Tomes, F.G.S., kindly determined the corals. The specimen of *Trigonia* obtained agrees with that figured by Lycett in his "Monograph of the British Fossil *Trigoniæ*," pl. xxxiv, fig. 9, as *T. pullus*; but not with the *T. pullus* of Sowerby.

There is no doubt whatever as to the age of the deposit, and the section is useful in that it affords an opportunity for investigating the lithic and faunal characters of the Great Oolite strata at the most northerly point at which they are preserved in the Cotteswold Hills.

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[1] In litt. July 7th, 1903.

V.—FURTHER REMARKS UPON THE CARBONIFEROUS ARACHNID *ANTHRACOSIRO*, WITH THE DESCRIPTION OF A SECOND SPECIES OF THE GENUS.

By R. I. POCOCK, F.Z.S., of the British Museum (Natural History).

IN the GEOLOGICAL MAGAZINE for June of this year I proposed the new specific and generic names *Anthracosiro woodwardi* for a Carboniferous Arachnid represented in the British Museum by a single specimen (No. 1551) from Coseley, near Dudley, that formerly belonged to the collection of Mr. Henry Johnson. A further communication from Dr. Frič, of Prague, drew my attention to three additional specimens, with the same history, numbered 1554, 1555, and 1556, and ticketed *Eophrynus*, sp. nov. No. 1555 is the under-side of a scorpion, without the tail; the others are referable to the genus *Anthracosiro*.

No. 1554 appears to belong to the same species as the type of *Anthracosiro woodwardi*. Unfortunately the prosoma is so crushed that no details of its structure can be deciphered, beyond a confusedly radial arrangement of certain of its component parts indicating the disposition of the coxæ, and a broad central longitudinal ridge representing presumably the median area of the carapace. The position and length of the legs is also shown; but nothing new concerning their structure can be made out. The rest of the fossil consists of the terga of the opisthosoma, the entire ventral surface being wanting, except apparently the inturned portion of the eighth, which exhibits very clearly the subcircular anal plate (tergum of the tenth segment), surrounded by the narrow and annuliform united tergal and sternal elements of the ninth.[1]

As in *A. woodwardi*, the external portions of the laminæ of the third, fourth, fifth, and sixth terga are defined by a groove and upturned; and no joint is visible between the laminæ of the eighth and the median area of the tergum from which they arise. Except that the hinder borders of the posterior terga are rather more recurved than in the type of *A. woodwardi*, there is very little difference between the two fossils; and, without a series of specimens to test the constancy of this feature, it would be rash to attach a specific value to it.[2]

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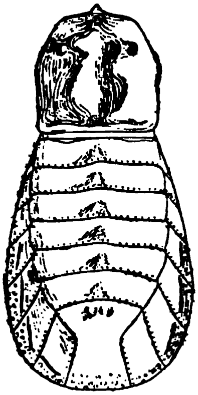
[1] I am unable to satisfy myself absolutely whether the two halves of the nodule exhibit the dorsal side of the terga and the impression of the same or the ventral surface of these plates and their impression; but I incline to the latter opinion on account of the distinctness of the anal sclerite and the lesser definition in detail presented by the half of the fossil showing what is either the dorsal surface of the terga or the impression of their under-side. So far as the structure of the plates is concerned, a definite decision on this point is a matter of no great moment; but the view here adopted carries the conclusion that the sternal elements have been entirely removed; whereas, according to the other hypothesis, the sterna remain in all probability buried in the stone.

[2] In the description of *A. woodwardi* I stated that a pair of tubercles is present upon the terga. This is an error. The tubercles appear upon the half of the fossil which is the impression of the dorsal surface. They therefore represent pits, not tubercles; and are doubtless to be referred to the paired muscular impressions characteristic of the terga of many Arachnida.

The other specimen, No. 1556, is the more important and instructive of the two. It is the fossil of a much smaller animal. One half of the nodule of clay-ironstone in which it is imbedded shows the dorsal surface; the other the impression of the latter. The chief feature of interest is the excellent state of preservation of the carapace. In the type of *A. woodwardi* this plate is crushed, showing nothing but the shape of its outline. Concerning its probable structure, I remarked that its crushed condition suggests that its median area was axially elevated, as in *Eophrynus prestvicii* and *Kreischeria wiedei*, and that it was justifiable to conclude that it was constructed essentially as in these genera. The fossil under notice proves the first suggestion to be true; the second false. The carapace is strongly arched, both longitudinally and transversely. From its highest point, which lies in advance of the middle, it slopes downwards, both anteriorly and laterally, and a pair of obtuse ridges, diverging somewhat abruptly from the middle line, then curving inwards and downwards, extends backwards almost to the posterior border of the carapace. The area between these ridges is widely and somewhat deeply excavated; externally to them the surface slopes downwards to the lateral margin. Anteriorly each ridge forms a smaller curve, also with its convexity outwards; and nearly midway between this and the lateral border there is a very distinct ocular tubercle. The outline of the carapace is almost exactly the same as that figured for *A. woodwardi*. There was possibly a small median process projecting forwards from the anterior border, and the posterior portion presents a short horizontal area as in the last-named form.



Anthracosiro fritschii, sp.n., dorsal surface. × 7½.

The tergal plates of the opisthosoma agree in the main with those of *A. woodwardi*, with the exception that the first is relatively much shorter. It appears upon the impression as a short sclerite, not half the length of the succeeding plate; but upon the fossil itself it is invisible, so that the opisthosoma appears to be supplied with but seven tergal plates on the upper side. The median line of these plates is elevated in the form of a triangular crest; that of the eighth is tubercular; and since the impression exhibits a multitude of close-set punctures upon the terga, it may be inferred that these plates were finely granular. This granulation is not apparent in *A. woodwardi*; but, as in that species, there is a row of coarser granules along the posterior border of the terga and of their laminæ, at least in the hinder half of the body. There is also a very distinct joint between the lateral laminæ of the eighth tergal plate and the area from which they arise. These joints are not visible in *A. woodwardi*. Towards the lateral border of the laminæ of the fifth, sixth, seventh, and eighth terga there is a distinct longitudinal groove; the area lying externally to this is bent upwards so that the dorsal surface of the opisthosoma is posteriorly scoop-shaped. The sculpturing of this area of the laminæ is more coarsely tubercular than the rest of the terga.

Total length 6·5 mm.; width of opisthosoma about 3 mm., length of prosoma 2 mm.

Since there is no reason to suppose that the differences between this specimen and the type of *A. woodwardi*, apart from the great discrepancy in size, can be attributed to age, there is no choice but to regard the two as representatives of distinct species. I propose to name this new form *Anthracosiro fritschii*, after Dr. A. Friĉ of Prague.

The characters of the two may be tabulated as follows:—

a. Terga of opisthosoma not granular throughout; the first large, more than half the length of the second, which has its anterior border mesially emarginate; joints between the proximal extremity of the lateral laminæ and the median area of the eighth tergal plate not apparent. Length from 17 to 21 mm. ... ... *woodwardi*, Poc.

b. Terga of opisthosoma finely and closely granular; the first very short, much less than half the length of the second, of which the anterior border is straight from side to side; joints between the laminæ and the median area of the terga of the eighth segment present. Length about 6·5 mm. *fritschii*, sp.n.

The two additional specimens of *Anthracosiro*, especially the one last described, make it possible to give a far completer diagnosis of the genus than could be based upon the single example of *A. woodwardi*. Pending the discovery of specimens showing fully the structure of the appendages and the ventral surface of the body, the diagnosis may run as follows:—Carapace vaulted, with a wide depression in the middle of its dorsal surface and a very short posterior transverse area. A pair of widely separated ocular tubercles in its anterior half. Upper side of opisthosoma presenting eight tergal plates, which are without tubercles, but are marked with a pair of muscular impressions; the first much shorter than the second; their anterior and posterior borders transverse, subparallel, scarcely or only slightly recurved at the posterior end of the body; laminæ rhomboidal, small at the anterior end of the bo gradually increasing in size posteriorly, the margins forming a continuous curve, those arising from the terga between and including the second and seventh directed obliquely backwards, their transverse axes inclined at an obtuse angle to those of the terga to which they are attached. Ninth segment annular, encircling the subcircular tergum of the tenth, which forms the anal valve.

In the above quoted paper describing *Anthracosiro woodwardi*, it was suggested that this genus should be classified in the same section as *Eophrynus* and *Kreischeria*. The discovery of the structure of the carapace as seen in *A. fritschii* shows this view to be untenable, and establishes the right of *Anthracosiro* to stand in a distinct family, if family rank be assigned, as has been done, to the analogous differences between *Anthracomartus* and *Eophrynus*. In the structure of the carapace *Anthracosiro* is more like *Anthracomartus* than *Eophrynus*, while in the structure of the opisthosoma it differs markedly from both.

The characters of the three groups may be tabulated as follows:—

a. Tergal laminæ of opisthosoma directed obliquely backwards, their transverse axes inclined at an obtuse angle to the transverse axes of the terga, which in the posterior half of the body are scarcely, if at all, recurved; carapace vaulted, widely depressed in the middle line above; eyes represented by a pair of widely separated tubercles situated a short distance above the lateral margin ... Anthracosironidæ.

b. Tergal laminæ of opisthosoma, with their transverse axes in all cases in the same line, whether curved or straight, as the transverse axes of the terga; terga in the posterior half of the body becoming gradually more and more recurved towards the anal extremity; eyes, when visible, close to the middle line of the carapace.

a'. Carapace flattish or evenly vaulted, not differentiated by deep grooves into definite elevated areas ... Anthracomartidæ.

b'. Carapace dorsally differentiated into a median lobate axial elevation and a lateral flat segmentally grooved area. Eophrynidæ.

For the characters of the genera referred to the Anthracomartidæ and Eophrynidæ, reference may be made to my paper entitled "*Eophrynus* and Allied Carboniferous Arachnida" in the GEOLOGICAL MAGAZINE for October and November of last year.

VI.—PHOTOGRAPHY IN GEOLOGY.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE XX.)

PHOTOGRAPHY has now become so invaluable an accessory to every branch of science, that it is not surprising to find it has proved indispensable alike to the geologist and the palæontologist. One has but to turn back over the four decades of this Magazine and compare the number and quality of the illustrations, in the earlier with the later years, in order to realize the great advances that have been made by the application of photography both 1 *process-plates* and to illustrations in the text (especially in the la quarter of a century), which has so enriched and enhanced th value and interest of this and other scientific journals. That goo half-tone process-blocks can be made from photographs of an geological subject taken in the field, is now well established nevertheless, two points are absolutely essential to their success (1) the photograph must be particularly clear and well-define in its details; (2) the block, however good, may easily be rendere worthless by bad or careless printing; moreover, it must b reproduced upon paper with a finely finished surface, although need not necessarily be the highly glazed kind (heavily loaded wit kaolin) now so much in vogue for the illustrated Monthlies.

The project of forming a large permanent public collection photographs, illustrating as far as possible the most importa features of geological interest in the United Kingdom, was initiate by Mr. O. W. Jeffs in 1888, who read a paper upon the subject at th Bath Meeting of the British Association in that year; and in th year following, a Committee[1] was appointed and Mr. Jeffs undertoo the management of the work, which he carried on for seven yea with indefatigable zeal and care, only relinquishing it when th size of the collection began to exceed the capabilities of priva control and the possibility of one person being able to devote th requisite time and attention to its custody. Up to the year 18 twelve hundred photographs had been obtained, and it was deeme advisable that the collection should be placed in the Library of th Museum of Practical Geology, Jermyn-street, where it has sin remained, and is available for reference to all those who take a re interest in or desire to make a proper use of it.

It is no easy task to arrange and catalogue such a collectio properly, and this has now been and is being done with the sanctio of the Director of the Geological Survey, under the careful supervisio of the Committee's indefatigable Secretary, Professor W. W. Watt M.A., Sec. Geol. Soc., and has already proved of the very greate use to geologists, whilst its ample store of beautiful illustrations a being constantly added to, and also drawn upon for purposes illustrating works on descriptive geology and physiography a for various textbooks.

The collection is moreover a permanent record of all the mo important features in the geology and scenery of our Islands, seen to-day; but very soon some important modification may ha taken place, and by to-morrow a storm, a landslip, or the actio of the sea may have changed the face of Nature at the spot d picted, and the now carefully preserved picture may be the on record of the interesting scene. Happily, we are not subject earthquakes or volcanic disturbances in this country, as in Ital New Zealand, or the West Indies, which might destroy a who district and bury up its towns; but, nevertheless, our coastline is so extensive, owing to its indented and insular character, that we are particularly exposed to the effect of storms and marine denudation, so that our shores have undergone or are undergoing many changes, some parts, like Sandwich, being deserted by the sea, and others, like Reculvers, Cromer, and Southwold, being eaten away by the waves. Cliff-sections, too, like those of Lyme Regis in Dorsetshire, and even harder rocks, like those of Muckros Head, co. Donegal (see Plate XX), are constantly subject to the destructive action of the sea, and even after a very few years undergo visible change of contour and recede before its erosive attacks. Quarry-sections and railway-cuttings, often of very great geological interest, are generally only to be seen temporarily; the former changing with the progress of the work of extracting the stone, chalk, or ballast, the latter too frequently being grassed over and otherwise rendered obscure by rainwash from the surface. These have to be photographed at once upon the spot, and this is not always easily accomplished. Thanks, however, to a great number of enthusiastic amateurs who have aided the Committee in its work, men like Professor E. J. Garwood, Professor E. W. Reid, Godfrey Bingley, A. K. Coomáraswámy, A. S. Reid, Professor S. H. Reynolds, J. A. Cunningham, W. L. Howie, G. J. Williams, and professional photographers like A. Welch, the British Association series of geological photographs has now attained a well-deserved and recognised importance and value.

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[1] For an earlier account of the work of the British Association Photograp Committee see articles by Professor W. W. Watts, M.A., Sec. Geol. Soc., GEOL. MAG., 1897, Dec. IV, Vol. IV, pp. 31–37, 62, and 109.

Among the various advantages offered by the Photographs Committee as the outcome of their labours are: the supply of (1) sets of geological photographs for use in museums, with appropriate letterpress, both mounted and unmounted; (2) sets of lantern-slides for geological lectures; (3) views for book illustrations, of which many authors have availed themselves even within the last twelve months.

It would be difficult, however, to define the limits of the usefulness of these admirable pictures to the writer, the teacher, the lecturer, the museum curator, the artists, and the public at large.

The second series of geological photographs published by the British Association Committee have just appeared. The set comprises 4 whole plates, 18 half plates, and 4 quarter plates, also a series of 26 lantern-slides.

The photographs are all copyright. Descriptions in pamphlet form accompany the photographs, and with the unmounted prints a set of labelling slips is sent.

The description which accompanies each photograph has been prepared with great care, either by the author of the photograph or by some active member of the Committee, and occasionally small sketches are added in the text, giving (diagrammatically) the geological details to be seen in the photograph.

For example, Professor Grenville A. J. Cole writes of the beautiful photograph taken by Mr. R. Welch (of 49, Lonsdale Street, Belfast), a copy of which forms the subject of Plate XX accompanying this notice:—

(p. 12.) "*No.* 1664. *Bedding and Jointing in Carboniferous Sandstone; Muckros Head, Donegal.*

Photographed by R. Welch; 1890.

At Muckros Head, in the west of Co. Donegal, an outlier of Lower Carboniferous sandstone and limestone runs out into the sea. The horizontal bedding and vertical joints control the weathering of the cliff, and ledges of more resisting rock project boldly from the wall. The two vertical series of joints are fairly perpendicular to each other. In certain beds lamination is well exhibited.

Grenville A. J. Cole."

Of the photographs dealing with volcanic subjects may be specially mentioned a fine example of a basalt dyke taken by Mr. R. Welch, (B.A.) 974, and described by Mr. W. B. Wright. The dyke is seen cutting through the chalk on the south side of Cave Hill, Belfast, co. Antrim. The chalk itself is converted into a hard white limestone, in which may be seen well-defined layers of flint. A flow of lava rests upon the eroded surface of the chalk, the latter being covered with a bed of flint gravel, most of the flints in which are stained a deep red colour.

Another fine photograph, also taken by Mr. R. Welch, is (B.A.) 1652, and represents a portion of the columnar basalt of the Giant's Causeway, co. Antrim, described by Professor T. G. Bonney, F.R.S.

(p. 18.) "*No.* 1652. *Columnar Basalt, Giant's Causeway, Antrim.*

Photographed by R. Welch; 1893.

Columnar jointing is rather common in basalt, and that of the Giant's Causeway affords excellent examples. As the structure is due to contraction in cooling the columns are usually six-sided (R. Mallet, Phil. Mag., ser. iv, vol. i, p. 122). Further contraction produces cross joints. These may be frequent, as in this instance, or at rather long intervals, as in the Siebengebirge. Their form varies; it is sometimes a plane; sometimes part of the surface of a large sphere, covering all the end except, perhaps, the angles, as with most of those in this photograph: sometimes an almost hemispherical dome rises in the middle of a flat roof. The curves, as can be seen, do not all point in the same direction. Occasionally spheroids, which may be concentric, form inside a column without external rupture, and are only exposed by weathering. A column in the bottom left hand corner shows a tendency to this structure, which also may be exhibited in the occasional fractures at the corners of the blocks. This is a result of the principle of least-action, but difficulties often arise in applying that to particular instances (Quart. Journ. Geol. Soc., xxxii, 1876, p. 140).

T. G. Bonney."

There is another volcanic picture, that of the well-known "Scuir of Eigg" (No. 2562), photographed by Mr. Arthur S. Reid, M.A., F.G.S., who also gives a detailed description of the same, and refers the reader to Sir A. Geikie's great work on the Ancient Volcanoes of Great Britain, 1897, vol. ii, pp. 236-248.

A fine example of erosion is seen in the photograph taken by Mr. E. A. Bush, of the Hemlock Stone, Stapleford Hill, Notts, described (p. 10, No. 2879) by Mr. Walcot Gibson, F.G.S. This stone is a column 31 feet in height and 70 feet in girth, and is an excellent illustration of erosion by wind action and atmospheric weathering.

Professor E. J. Garwood contributes a beautiful photograph (No. 624) and description (p. 17) of the intrusive igneous sheet in Carboniferous rocks known as the Whin Sill, High Force, Teesdale. This is a classical waterfall described by Sedgwick in 1823. The fall is 70 feet high over the Whin Sill, which is here intrusive in the Lower Yoredale Beds.

A photograph by Mr. Godfrey Bingley (No. 1912) representing the upper course of a stream—"High Cup Gill," near Appleby, Westmoreland—is described by Professor E. J. Garwood (on p. 15). It depicts a typical V-shaped valley, joining that of the Eden from the eastern side. The Gill is excavated in the Lower Carboniferous beds against the dip of the strata (down the scarp side), and the old dip-valley, draining down eastward to the Tees, is seen on the right side of the photograph.

Another example of Mr. R. Welch's fine Irish photographs is

(p. 10.) "*No.* 963. *Pot-hole in Basalt, Glenariff, Co. Antrim.*

This is a very typical example of a circular hole in the bed of a stream drilled by means of pebbles swirled round in eddies of the water when the stream carries an ample current. The hard pebbles are probably provided by the Boulder-clay in the neighbourhood of the glen. Such holes are remarkably circular in plan, with their sides well smoothed and polished, while the pebbles become ovoid and very well-rounded. Further down stream there are other very deep pot-holes, and gorges excavated partly by pot-hole action. A scale is given by the vegetation.

W. W. Watts and R. Welch."

At p. 14 Professor James Geikie, Chairman of the Committee, describes (No. 1815) a small photograph, which we could wish was larger, but which will no doubt make an admirable lantern-slide, representing the historical Parallel Roads of Glenroy, looking N.N.E. from the northern slope of Bohuntine Hill, about half a mile south of Achavady, Argyllshire.

"Photographed by W. Lamond Howie; 1896.

The 'Parallel Roads' are narrow terraces or benches, 40 to 50 feet in width, running horizontally and parallel to each other along the mountain slopes. They are not flat, but have an inclination of 12° to 20° or thereabouts. They consist chiefly of angular detritus of local rocks, mostly overgrown with vegetation. Originally considered by Darwin and others to be sea-beaches, they are now generally admitted to mark the successive levels of a glacier-dammed lake. The 'roads' are seen in this view on the east side of the glen, at heights of 1,153, 1,077, and 862 feet respectively, heights which correspond with three cols, one at the head of the main glen, one on a left-hand tributary, Glen Glas Dhoire, and one at the head of Glen Laggan, into which the lowest 'road' passes.

James Geikie and W. Lamond Howie."

Did space and means permit, we should like to present to our readers reproductions of all of these excellent and instructive pictures with their accompanying descriptions, but instead we strongly recommend them to send a guinea to Professor W. W. Watts, M.A., Sec. G.S., Holmwood, Sutton Coldfield (Secretary of the British Association Geological Photographs Committee), who will cause to be sent to them 20 unmounted platinotypes with appropriate letterpress—or, still better, they may engage to send one guinea *annually*. For 30*s*. they will receive 20 mounted platinotype views on cards, and for £1 5*s*. 20 lantern-slides with letterpress may be obtained.

We cannot conceive of a more delightful present to make to a young, or old, geologist than one or both of the above charming series, or 20 *annually* as a birthday or New Year's gift!

NOTICES OF MEMOIRS, ETC.

I.—Cretaceous Cephalopoda from the Hokkaidō. Part I: *Lytoceras, Gaudryceras,* and *Tetragonites.* By Hisakatsu Yabe, Geological Institute, Science College, Imperial University, Tōkyō. Journal of the College of Science, Imperial University, Tōkyō, Japan, vol. xviii, Art. 2. pp. 55; 7 plates. 1903 (published 8th June).

THE Hokkaidō forms part of the Japanese empire; it lies to the north of the mainland, and consists chiefly of the island of Yezo or Yesso, having an area about equal to that of Scotland and Wales combined. The occurrence of Cretaceous Ammonites in the island was first mentioned by B. S. Lyman in 1877, and his collection, comprising some fifteen species of Cephalopoda, was briefly described three years later by Naumann. In 1890, in his work on the fauna of the Japanese Cretaceous rocks, Professor Yokohama more fully described the Cretaceous Cephalopoda of the Hokkaidō; but it was not until the island had been geologically surveyed by Professor Jimbō and his assistants that the nature and extent of the Cretaceous deposits there were known.

The Cretaceous formation in the main island of the Hokkaidō rests upon Palæozoic rocks, and is overlain by coal-bearing rocks; it extends in a north-south direction on the west side of the main axis of the island; it is a purely marine deposit, its fauna being very rich in Mollusca, particularly in Cephalopoda. Although the author of the present memoir went to the Hokkaidō mainly for the purpose of ascertaining the relation of the Cretaceous Ammonite-bearing deposits to the coal-bearing series, he made a large collection of Cretaceous fossils and carefully examined the stratigraphy of the Cretaceous rocks. He proposes the following subdivisions, beginning from below:—

I. The lower Ammonite-beds with *Orbitolina*-limestone.
II. The *Trigonia*-sandstone.
  a. Lower *Acanthoceras*-zone or *Trigonia longiloba*-zone.
  b. *Thetis*-zone.
  c. *Pectunculus*-zone.
III. The upper Ammonite-beds.
  a. Upper *Acanthoceras*-zone.
  b. *Scaphites*-beds.
  c. *Pachydiscus*-beds.

According to the author all the beds are quite conformable to each other, the upper ones passing gradually into the coal-bearing series.

Various opinions respecting the age of the Cretaceous rocks of the Hokkaidō have been expressed, but the author reserves the discussion of the nature of the fauna until the end of his memoir.

The whole of this part of the present memoir deals with the description of those Ammonites which were formerly included in the genus *Lytoceras*, but which are now separated into *Lytoceras*, *Gaudryceras*, and *Tetragonites*. Upon Uhlig's group of *Lytoceras Sacya* A. de Grossouvre founded the genus *Gaudryceras*; from this Kossmat separated two other types which he named *Tetragonites* and *Pseudophyllites*, regarding all three forms as subgenera of *Lytoceras*.

Pseudophyllites, so far as at present known, is represented by only one species, *P. indra*. Naumann recorded from the Hokkaidō a new species allied to *P. indra*, but according to Professor Yokohama the specimen is much too fragmentary for specific determination, and unfortunately the collection made by the author did not include an example of the species.

Lytoceras, s. str., is represented by two species, both of which are new.

Gaudryceras can be divided into two well-marked sections, the one containing *G. Agassizianum* and *G. Marut*, the other being the group of *G. Sacya*. All the species of *Gaudryceras* are very imperfectly known. "This," says the author, "is partly due to the fact that, although they are very common especially in the Upper Cretaceous deposits of the Indo-Pacific region, the specimens usually belong to immature animals, and consequently closely resemble one another, so that the determination is not only very difficult, but often quite impossible. Moreover, the aspect of the shell of this genus is so different in its younger and older stages, that without a large series of specimens for comparison, the larger and smaller forms are often liable to be separated into distinct species." All the *Gaudryceras* from the Hokkaidō belong to the group of *G. Sacya*, which the author subdivides into six subgroups, based mainly upon the character of the full-grown shells; four new species and a number of new varieties are described.

In the genus *Tetragonites*, besides the species described by Jimbō as *Lytoceras glabrum* and recognized by Kossmat as belonging to this genus, the author places Professor Jimbō's *Lytoceras sphæronotum* and *Lyt. crassum*.

Judging from the figures and the detailed observations which the author has been able to make on some of the species, it seems that, like the fossils from the Upper Cretaceous rocks of Southern India, the specimens are exceedingly well-preserved.

We most heartily congratulate the author upon his work, and hope ere long to have the pleasure of seeing a further portion of his memoir.

G. C. C.

II.—REPORT OF THE STATE GEOLOGIST (GEORGE H. PERKINS) ON THE MINERAL INDUSTRIES AND GEOLOGY OF CERTAIN AREAS OF VERMONT. pp. 191, with 64 plates. Albany, New York, 1902.

THIS volume, for 1901–2, is the third of the series issued by the present State Geologist. It includes biographical sketches of two old Vermont geologists—Zadock Thompson (1796–1856) and Augustus Wing (1808–1876)—and gives a bibliography of the official and other publications relating to the geology of the State. The only mineral products of any economic importance are asbestos and building and ornamental stones, and the report on the mine industries extends to only 15 pages. The bulk of the volume occupied by the following articles:—

"The Granite Area of Barre," by G. I. Finlay.

"The Terranes of Orange County, Vermont," by C. H. Richards

"The Geology of Grand Isle," by G. H. Perkins.

"Petrographic Description of the Dikes of Grand Isle," H. W. Shimer.

III.—Plumasite, an Oligoclase-Corundum Rock near Span Peak, California. By A. C. Lawson. Bull. Dep. Geol. Un California, 1903, vol. iii, pp. 219–229.

IN 1898 Morozewicz proved experimentally that corundum capable of crystallising from an igneous magma containing excess of alumina; since then corundum-syenites have been describ from India, the Urals, Ontario, and Montana. Previously, corund had not been recognised as an essential constituent of igneous roc

The corundiferous igneous rock now described occurs as a dy 15 feet in width, intersecting amphibole-peridotite. It is compo of a coarse allotriomorphic granular aggregate of white oligocl with embedded crystals (acute rhombohedra) of pale violet-b corundum, the two minerals being present in the proportion 84 to 16 respectively. To this new type of rock the name Plumasi from the locality, Plumas County, is given. The rock of ot portions of the same dyke consists only of white felspar with corundum.

IV.—Palacheite. By A. S. Eakle. Bull. Dep. Geol. Un California, 1903, vol. iii, pp. 231–236.

THE mineral to which this new name is given occurs abundan as a recent formation in the old workings of the Reding mercury mine, Knoxville, California. The brick-red crystals monoclinic, and their chemical composition is expressed by formula $Fe_2O_3 . 2\,MgO . 4\,SO_3 + 15\,H_2O$. Although stated to a new mineral, it is not proved to differ essentially from imperfectly described rubrite.

REVIEWS.

I.—A Great Catalogue of Books on the Natural Science

Catalogue of the Books, Manuscripts, Maps, and Drawings in British Museum (Natural History). Vol. i, A–D (500 pp.). Bernard Barham Woodward. 4to. London: printed order of the Trustees, 1903. Price £1.

WHEN the Departments of Zoology, Geology, Mineralogy, a Botany were housed at Bloomsbury, each had its own sm library of working books, but obtained such other works as w required from the great library of the Printed Books Departme When these Departments were removed to Cromwell Road

1880–1883, it became necessary to form a new library for their requirements, and a special vote was obtained from Parliament for this purpose. The Departmental libraries were retained and added to, while a 'General Library' was formed to receive such books whose subject-matter concerned more than one of the special Departments. By this means much needless duplication was avoided. Accessions are constantly being made by purchase, donation, or exchange, and though there are still some 'desiderata,' it is not too much to say that this collection of works on Natural History is one of the finest and most complete ever brought together. This is especially the case with serial publications and works issued by Academies, in many of which the wrappers have been preserved, that are so important and valuable in these days of contested priority in nomenclature.

In 1881 Mr. B. B. Woodward was transferred from the Printed Books Department to South Kensington, and placed in charge of the new General Library then being formed, while he subsequently had general charge of the cataloguing of all the collections of books in the building. It is to his careful and exact knowledge of books and special knowledge of the requirements of workers in Zoology and Geology, that we owe many of the literary treasures in the British Museum (Natural History). Working at first alone, and in later years with the intelligent assistance of his attendant Mr. Charles Leigh and afterwards of Mr. C. Hadrill, and a clerical assistant, he has catalogued this grand collection of scientific books from a bibliographical standpoint, and the present volume (the first of four) is the fruit of his labours.

Since the whole of the manuscript is almost finished, we may hope in a very few years to have the complete work before us, and when using it daily shall be able to form some slight idea of the thought and labour bestowed upon its production. Constant use both of the MS. and of the proofs for many years, allows the writer to state that it is undoubtedly the most complete and exact catalogue of scientific publications (other than *separata*) ever printed.

Each entry in the catalogue is complete in itself, thus allowing it to be cut up for a card catalogue, a system of course in vogue at the Natural History Museum.

The entries are arranged under the names of the authors, but should no author's name appear, the work is entered under the principal word of the title, preference being given to such as most clearly defines the contents.

Societies and Corporate Bodies are considered to be the authors of their publications, and are entered—(*a*) English, Colonial, and American Societies, with such others as are not local, directly under their proper name; (*b*) all others under the name of the place in which their headquarters are situate.

Official accounts of Surveys and Explorations undertaken by any Government are placed under the name of the country issuing them.

Magazines and Journals of a similar character are entered under the first words of the title, omitting articles.

Maps are entered in the first instance under the name of the country charted.

Cross-references are given freely in all cases where they will facilitate research.

Titles in Russian, Servian, Japanese, and other Eastern languages have been transliterated and translated, help in this direction having been freely given by Professor R. K. Douglas, members of the Japanese Embassy, and members of the staff of the Printed Books Department at Bloomsbury.

Mr. Woodward also acknowledges assistance received from Dr. Henry Woodward, Dr. Arthur Smith Woodward, Mr. L. Fletcher, Mr. J. Britten, Professor F. J. Bell, Mr. G. C. Crick, Mr. G. A. Boulenger, Dr. F. A. Bather, and others.

Referring to the exactitude with which the work has been done, let us turn to BERENDT (G. C.). The first entry gives his name in full and his birth and death dates, and lists a tract; the second entry chronicles his "Die im Bernstein befindlichen organischen Reste . . . gesammelt . . ." The separate papers in this work are fully plotted out, and thus we have an entry concerning five works, of which the ordinary catalogues merely give the covering title. Let us now refer to BUFFON. We find no less than ten editions of his "Complete Works," of which two, if not three, are not to be found elsewhere in England, all of which are fully listed out, and the date for each volume of each series inserted. Even the "Guides des Excursions" of the Geological Congresses held at Zurich and St. Petersburg are fully listed as to their separate papers. With regard to those troublesome publications which are issued a few pages at a time and extend over a term of years, afterwards to be bound up as an ordinary book, and all records of date lost, Mr. Woodward has, whenever possible, either supplied the facts himself or given a note as to where they may be found. Many of these entries, occupying but a few lines of print, may mean hours, days, or weeks of hunting of the most wearisome description through contemporary literature. In this connection he has inserted a great deal of the matter collected by the writer while compiling his "Index Animalium." The irritating practice of authors of using one only of their christian names, or of using their surname hyphened to the last christian name without legal title, or of using the surname only, have all been dealt with, and many errors of this nature that have unavoidably crept into earlier catalogues have now been cleared up. We no longer read such a jumble as the fertile mind of an Indian babu elaborated for the catalogue of a well-known Indian library:—

BUFFON, de.
———, Le Citoyen la Cepède.
———, le Comte de.
———, le Comte de la Cepède.
———, le Clerc de.
See also Lacepède,

and though we have searched minutely for errors of any kind in the work before us, they are not only rare, but of trivial importance.

Among other important things from a bibliographical point of view, are the careful distinction between President and Respondent in the older Dissertations; the fact that the title is an exact transcript of the original so far as it goes, omissions being recorded by " . . . ", and additions being made in square brackets; and the transliteration and translation of Eastern titles.

We have brought thus fully to our readers' notice this catalogue of books because we feel that in these days of strain every solid step in the ladder of help is worth recording, and there is so much here that will save the time of the geologist, and the zoologist, whether he cares to deal exclusively with fossil or recent animals, or both. Its value also to small or incomplete libraries is almost beyond expression. At all events, when considering the date of a book or part of a book, or the proper name of an author, or the exact form of a publication (whether separate or an extract from an Academy or Serial), it will be found in future absolutely necessary to see what Mr. B. B. Woodward has had to say upon the matter in his "Catalogue of the Books, etc., in the British Museum (Natural History)."

C. D. S.

II.—THE ORIGIN OF LAKE TANGANYIKA.

The Tanganyika Problem: an Account of the Researches undertaken concerning the Existence of Marine Animals in Central Africa. By J. E. S. MOORE, F.R.G.S. pp. xxiv, 371, with text-figures, maps, and plates. London: Hurst & Blackett, 1903.

IN 1857 the late Dr. S. P. Woodward described two univalve shells of a remarkably marine aspect from Lake Tanganyika. In 1881 Mr. Edgar A. Smith announced the discovery of several other specimens of obviously marine relationships in the same lake. The German traveller, Dr. Böhm, subsequently found Medusæ with these shells, and when they were examined they were found to be quite unlike any known forms and probably of an ancient type. The freshwaters of Lake Tanganyika were therefore suspected to contain the relics of an ancient marine fauna, the lake itself, indeed, being the altered remnant of a former sea.

To investigate the problems thus suggested Professor Ray Lankester and a small committee organized an expedition, which was despatched under the leadership of Mr. J. E. S. Moore in the Autumn of 1896. The results of their investigations, communicated to the Royal Society and to various scientific journals, were so important that a second expedition was organized under the same leadership in 1899. A remarkable work was accomplished, and Mr. Moore has summarized the principal facts and conclusions in the beautiful volume now before us. The results of a purely scientific investigation have rarely been presented in so attractive a form, illustrated not merely with artistic drawings of the animals, but also with the author's own coloured sketches of the scenery.

It is evident that if Lake Tanganyika is a remnant of an ancient sea, many of the problems connected with it are essentially geological. Although the work is that of a zoologist, it thus presents many features of great interest to readers of this Magazine. In attempting to study it, they will only regret that, while the author recognizes and discusses the geological bearings of the subject, he displays such a lack of acquaintance with the elementary principles of the science that the result is not so satisfactory as could be wished.

By way of introduction, Mr. Moore devotes a chapter to the origin of fresh-water faunas in general, and considers that the more widely-spread members of these faunas were all derived from the sea at one time—"at a period roughly corresponding to the commencement of the formation of the Secondary rocks." He thinks that increasing salinity of the sea-water caused this migration. The more strictly local fresh-water types are regarded as being of comparatively recent origin.

The special case of Tanganyika is then discussed, firstly from the geological and geographical point of view, and secondly from the zoological standpoint. No new geological facts of importance are recorded, but an interesting summary of the work of previous observers is given. The peculiar 'gräben' or 'rift-valleys,' so characteristic of the Tanganyika region, are unnecessarily renamed 'eurycolpic folds.' The Permo-Carboniferous rocks discovered by the late Professor Drummond on the shores of Lake Tanganyika are also misunderstood, and assumed to be marine sediments. In fact, there is at present no foundation for Mr. Moore's statement "that at some time there was in this region a fauna consisting at any rate of ganoid fishes, echinoderms, and molluscs, or, in other words, a marine fauna; and that these things entirely disappeared through the great physical changes and displacement which occurred during the extension of the Nyassa fold into this particular area." If truly marine deposits exist in the region in question they still remain to be discovered.

The most important zoological result of Mr. Moore's researches is, that although he made large collections he never found the supposed marine shells and medusæ in any lake except Tanganyika, while he did not discover any striking new types, except possibly a Polyzoan which has not yet been fully investigated. This circumstance is all the more remarkable since Mr. Moore obtained nearly 200 new species of animals referable to the typical modern fresh-water fauna of Africa. The fishes, described by Mr. Boulenger, and beautifully illustrated, are especially noteworthy, for they are all essentially present-day types, and do not in any way represent survivors from the seas of the Secondary period.

The precise affinities of the medusæ are still to be determined, but Mr. Moore has examined the anatomy of the univalve molluscs in great detail and with remarkable skill. He concludes that the characters of the shell afford a very slight clue to the true relationships of the animal to which it belongs. We can thus place little reliance on his interesting comparison of the univalves of Lake Tanganyika with certain shells of similar shape and ornamentation from the Jurassic rocks of England. His beautiful illustrations, however, show that there is a most striking resemblance between the recent and fossil shells to which he refers.

Mr. Moore describes these univalve mollusca, the medusæ, and certain more doubtful animals as a "halolimnic fauna"—a stranded relic of an old marine fauna which has been little changed by isolation. He accounts for their presence by supposing that Tanganyika was connected with the sea during some part of the Secondary period by way of the Congo basin. There still remains, however, the difficulty that the halolimnic fauna is not found either in the neighbouring lakes or in the old sediments which have been examined round their margins. We are, indeed, greatly indebted to Mr. Moore for stating the Tanganyika problem more clearly and definitely than it was ever done before, rather than for proposing an adequate solution of it.

III.—MATHEMATICAL CRYSTALLOGRAPHY AND THE THEORY OF GROUPS OF MOVEMENTS. By HAROLD HILTON, M.A. 8vo; pp. 262. Oxford: at the Clarendon Press, 1903.

AT the last Oxford Meeting of the British Association, held in the year 1894, the President of the Geological Section attempted to explain in simple language some of the most important recent developments of the theories of crystal-structure, then only on record in isolated memoirs, almost all of them foreign. Mr. Hilton, in the present work, has taken the same problem in hand; he has collected for the benefit of geologists and others the results obtained by Fedorow, Schönflies, and Barlow, and has arranged them in orderly sequence in twenty-six chapters. Beginning, in Part I, with a brief explanation of the stereographic projection, the author passes at once to the discussion of Homogeneity and the limited number (32) of finite groups of movements which are consistent with the law of rational indices and are therefore applicable to Crystallography; and then considers the dependence of the physical properties of crystals on the Symmetry. In Part II the author enters into the consideration of the Structure-theory. If a collection of molecules can be brought into self-coincidence by an operation, such an operation is termed a 'symmetry-operation'; all the symmetry-operations proper to the collection of molecules are said to form a 'group'; the author thereupon proceeds to evolve the 230 distinct groups which are geometrically, not necessarily mechanically, possible in homogeneous matter. Mr. Hilton next considers the regular partitioning of space, and mentions the interesting case in which space is partitioned by Lord Kelvin into 14-walled cells, all of them similar and similarly orientated, the walls being not in general plane. A final chapter gives a history of the Structure-theories. The book is illustrated with no fewer than 188 figures, some of them of a remarkably complicated character. Everyone interested in crystals will feel deep gratitude to Mr. Hilton for having so successfully undertaken a very difficult task, and to the University Press for having in this praiseworthy way made the work immediately accessible to the student.

REPORTS AND PROCEEDINGS.

I.—THE NORFOLK AND NORWICH NATURALISTS' SOCIETY, NORWICH.

ADDRESS BY THE PRESIDENT, HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S., F.G.S., Late Keeper of Geology, British Museum, to the Members of the Norfolk and Norwich Naturalists' Society, at their Thirty-fourth Annual Meeting, held at the Norwich Castle Museum, March 31st, 1903.[1]

After some preliminary matters relating to the affairs of the Society, the President read his anniversary address, entitled "The Distribution of Life in Antarctic Lands."

INTRODUCTORY—GLACIAL AND INTERGLACIAL PERIODS.—During the past sixty years astronomers, physicists, meteorologists, and geologists have all laboured to elucidate the causes and extent of the *Glacial period*, or, to speak more correctly—*periods*.

It seems certain that such epochs have been, in great measure, brought about by a combination of astronomical causes, such as the inclination of the earth's axis, the ellipticity of her orbit, and her position in relation to the sun in perihelion and aphelion. But to whatever combination of causes such alterations of climate in the northern and southern regions of our globe may be due, we have a right to demand from the astronomers and physicists the concession that mild Interglacial periods of considerable duration must have prevailed at or near the poles, certainly within Tertiary times. Sir Robert Ball says: "It is essential to the astronomical theory of the Ice Age that such interglacial and glacial periods must have alternated with one another at the opposite poles of our earth."

The facts of the occurrence of extensive beds of coal and lignite, associated with shale-beds rich in leaves of dicotyledonous trees and shrubs in Arctic America, in North Greenland, Spitzbergen, etc., within the Arctic circle; and beds of coal with abundant tree-trunks in Kerguelen Island,[2] Chatham Island,[3] etc., in the Antarctic, where no trees now exist, testify to great changes of temperature in the circumpolar regions of our earth, such as would, if they recurred, render these lands again habitable by plants and animals belonging to warmer temperatures, and greatly reduce, if not entirely remove, all traces of snow and ice over these areas.

Let us take a glance at the two polar regions of our earth. First: let us note the fundamental difference between Arctic and Antarctic conditions as regards topography. In the Northern Hemisphere there is a polar sea almost completely surrounded by continental land, and continental conditions for the most part prevail. In the Southern Hemisphere there is almost certainly a continent at the South Pole, which is completely surrounded by the ocean, and the most simple and extended oceanic conditions are met with.

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[1] Reprinted from the Transactions of the Norfolk and Norwich Naturalists' Society, vol. vii, pt. 4, and issued to members 20th August, 1903.

[2] 50° S. lat. Kerguelen Island.

[3] 45° S. lat. Chatham Islands.

Below the parallel of 40 ° South latitude lie Tasmania, the South Island of New Zealand, numerous small islands (such as the Chatham Islands, Auckland Island, Campbell Island, Macquarrie Islands, Kerguelen Island, Heard Island, Prince Edward Islands, Tristan da Cunha, Gough Island, Bouvet Island, South Georgia, Sandwich Group, South Shetland and South Orkney Islands, Falkland Islands), and about 1,500 miles linear of the South American Continent, Tierra del Fuego and Cape Horn. At the pole itself lies the great unexplored Antarctic Continent, surrounded by the vast waters of the Southern Ocean, covering an area of 30,000,000 square miles.

ATMOSPHERE. — Over the area, south of the parallel of 50° S. latitude, a temperature below 32° Fahr. prevails. South of latitude 45° S. we meet with low atmospheric pressure all the year with strong westerly and north-westerly winds, and large rain and snowfall all round the South Polar regions, the mean pressure being less than 29 inches. But there are many indications that the extreme South Polar area is occupied by a vast anticyclone, out of which winds blow, towards the girdle of low pressure outside the ice-bound region. Ross found a gradual rise of pressure south of latitude 75° S., and all Antarctic voyagers agree that when near the ice the majority of winds are from the south and south-east, and bring clear weather with a fall of temperature, while northerly winds bring thick fogs with rising temperature.

ANTARCTIC ICE.—The most striking feature of the Antarctic is the huge table-shaped icebergs. These flat-topped icebergs have a thickness of 1,200 to 1,500 feet, marked by regular stratification, and presenting lofty perpendicular cliffs, which rise 150 to 200 feet above, and sink 1,100 or 1,400 feet below the level of the sea.

Their form and structure clearly indicates that they were formed on an extended land surface, and have been pushed out over low-lying coasts into the sea.

Ross sailed for 300 miles along the face of a great ice-barrier from 150 to 200 feet high, off which he obtained depths of 1,800 and 2,400 feet. This was evidently the sea front of a great creeping glacier or ice-cap just then in the condition to give birth to those table-shaped icebergs, miles in length, which have been described by every Antarctic voyager.

But all the Antarctic land is not surrounded by inaccessible cliffs of ice, for along the seaward face of the great mountain ranges of Victoria Land the ice and snow which descend to the sea apparently form cliffs not higher than ten to twenty feet; and in 1895 Kristensen and Borchgrevink landed at Cape Adare on a pebbly beach, occupied by a Penguin rookery, without encountering any land-ice descending to the sea.

Where a Penguin rookery is situated we may be quite sure that there is open water for a considerable portion of the year, and consequently landing might be effected without much difficulty or delay. A party once landed might with safety winter at such a spot, where Penguins would furnish an abundant supply of food and fuel.

A properly equipped party of observers situated at a point like this on the Antarctic Continent for one or two winters might carry out a most valuable series of observations, make successful excursions towards the interior, and bring back valuable information as to the probable thickness of the ice-cap, its temperature at different levels, its rate of accumulation, and its motion. As to the evidence of an Antarctic Continent, the form and structure of the Antarctic icebergs show that they were built up on and had flowed over an extensive land surface. As they float north and break up in warmer latitudes they distribute over the floor of the ocean large quantities of glaciated rock-fragments and land detritus.

These materials have been dredged up by the "Challenger" in considerable quantities, and show the rocks of this land to be gneisses, granites, mica-schists, quartz-diorites, sandstones, limestones, and shales; indicating continental land, and were clearly transported from land at the South Pole.

Rocks.—D'Urville describes rocky islets off Adélie Land composed of granite and gneiss. Wilkes found on an iceberg, near the same place, boulders of red sandstone and basalt. Borchgrevink and Bull fragments of mica-schists and other continental rocks from Cape Adare. Dr. Donald brought back a piece of red jasper or chert containing Radiolaria and Sponge spicules from Joinville Island. Captain Larsen brought from Seymour Island pieces of fossil coniferous wood, and fossil shells of *Cucullœa*, *Cytheræa*, *Cyprina*, *Teredo*, and *Natica*, having a close resemblance to species of lower Tertiary age in Patagonia, etc. These fossil remains indicate a much warmer climate in these areas in times past.

It is not to be expected that a living land-fauna will now be discovered beyond the Penguin rookeries. *Fossils* will, however, throw important light upon the age of the Antarctic land.

As Tertiary, Mesozoic, and Palæozoic fossils have been freely met with in Arctic regions, we are justified in anticipating the discovery of like forms on the Antarctic lands, with corresponding former climatic changes, such as the presence of these forms of life would demand.[1]

Kerguelen Islands, Lat. 49° 20′ S., Long. 69° 24′ E.—In Sir James Clark Ross's voyage to the Antarctic (1847, 2 vols., Murray), he visited the Island of Kerguelen in 1840, and records the occurrence of a bed of coal, four feet thick and 40 feet in length (exposed), near Arched Point, Christmas Harbour, 30 feet above the sea, and covered by basalt. On the north side of the bay formed by Cape François is a thin seam of coal (two or three inches in thickness) covered by a kind of 'slag' and by basalt. Silicified trunks of trees are also met with, some of which (brought home by Sir Joseph Hooker) are preserved in the British Museum.

The coal is described as slaty, of a brownish-black colour, and the fracture is like wood-coal. Both the wood and the coal-seam are probably of Tertiary age. (A trunk of a large tree, seven feet in circumference, and much silicified, was dug out of soil below the basalt.) The wood, which for the most part is highly silicified, is found enclosed in the basalt, whilst the coal crops out in ravines, in close contact with the overlying porphyritic and amygdaloidal greenstone.

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[1] See Sir John Murray, Proc. Roy. Soc., vol. lxii (1898), pp. 424–451.

Ross mentions another bed of coal in Cumberland Bay, one foot in thickness (light and friable with a black glossy fracture like cannel coal, which does not soil the fingers). It is covered by a porphyritic amygdaloidal and greenstone rock. Another bed of coal in an adjacent hill is two feet thick, of a dull brownish-black colour; and it is said to burn very well.

When Captain Cook visited Kerguelen in the height of Summer (1768) the land was covered with snow, and only five plants in flower were collected. The observations were made by Surgeon Robert McCormick and Assistant-Surgeon Joseph D. Hooker, of the "Erebus" (1839–43). Hooker records 150 living plants—18 flowering plants, 3 ferns, 25 mosses, 10 *Jungermanniæ*, 1 fungus, the rest (93) lichens and seaweeds.

Mr. R. McCormick, who accompanied Ross, wrote:—"Since the successive overflowings of volcanic matter destroyed the forests which at one period clothed this land, of which the fossil trees and numerous beds of coal afford abundant proof, it has remained in a state of almost vegetable desolation ever since."

Writing of Victoria Land, Sir James Ross in February, 1841, said: "Had it been possible to have found a place of security upon any part of this coast where we might have wintered in sight of the brilliant burning mountain (*Erebus*), and at so short a distance from the magnetic pole; both of these interesting spots might easily have been reached by travelling parties in the following Spring. It was, however, some satisfaction to know that we had approached the pole some hundreds of miles nearer than any of our predecessors."

And here I may record that on March 26th, 1903,[1] Relief Ship "Morning" sends us good news from Port Lyttelton, New Zealand; and we know that Commander Scott with his crew in the "Discovery" entered the Antarctic Ice-pack on 23rd December, 1901, lat. 67° South, reached Cape Adare on 9th January, 1902, Wood Bay on 18th January, and landed on 20th in an excellent harbour, lat. 76° 30′ South, visited Cape Crozier on 22nd, examined the ice-barrier, and took soundings in long. 165°, and found that the ice-barrier trended northwards. High snow slopes rose towards the glaciated lands with occasional bare precipitous peaks. They followed the coast as far as lat. 76°, long. 150° 30′; and then retired to winter quarters in McMurdo Bay, Victoria Land. Sledge-parties reached lat. 80° 17′ South, the furthest point ever attained. Ranges of high mountains were seen to continue through Victoria Land. Foothills resembling the Admiralty range were observed at 160°. Lowest temperature 62° below zero!

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[1] Fuller details are now before the public since the date of this address, March 31st, 1903, which, however, was not issued until 20th August, 1903, in vol. vii of Trans. N. & N. Nat. Soc., Norwich.

Dr. J. W. Gregory, F.R.S. (*Nature*, April 25th, 1901), following Bernacchi's "Topography of South Victoria Land" (Roy. Geog. Soc., March 18th, 1901), suggested various problems for the "Discovery" to work out.

(*a*) Whether the Antarctic lands to the south of Australia, Victoria Land, Wilkes' Land, Adélie Land, Geikie Land, Newnes Land, Termination Land, are all part of one great continent, or members of an Antarctic Archipelago.

The earlier voyagers all maintained the existence of an Antarctic Continent, and Suess' theory supports this view.

Ritter suggests that the volcanic chain forming the eastern face of Victoria Land is the continuation of the New Zealand volcanic line, and that the coast of Wilkes' Land is a southern extension of the Australian plateau. This plateau is bounded to the north and east by the great fold passing through New Guinea, New Caledonia, and New Zealand.

The rocks dredged by the "Challenger" and the "Valdivia" are like those of Southern Australia; and those of Victoria Land, examined by Teall, are like the rocks of New Zealand. Geologically, then, the Antarctic is an Archæan land with rocks similar to those of Australia; and its eastern side is volcanic.

Indirect evidence favours a land connection with a chain of peaks stretching from Victoria Land and the vicinity of Mounts Erebus and Terror to Graham's Land.

If this great line can be proved, the volcanic chain encircling the Pacific Ocean will be rendered complete, joining up the Antarctic land with New Zealand and Australia on the one hand, and Graham's Land to South America on the other. We do not expect a land fauna on the Antarctic, but Secondary and Tertiary fossils may be discovered, and furnish still further evidence of an old land connection.

Correspondence in North and South Conditions, or 'Bipolarity,' and Bipolar Faunas.—There is an interesting question, too, in reference to the littoral and shallow-water fauna and flora of the Antarctic lands as compared with the Arctic.

The *Sirenia* are represented in the south by *Halicore australis*, off the coast of Queensland, Australia, 30° only south of the equator, whilst *Rhytina gigas* (= *R. Stelleri*) occurs in peat-deposits on Behring Island, and was living in numbers around its shores as lately as 1750, 60° north of the equator. Probably in earlier times *Halicore*, or its allies, may have extended southwards to the shores and islands of the Antarctic lands.[1]

Of the Cetacea, the genus *Balæna* is represented in the Arctic seas by *B. mysticetus*, *B. Biscayensis* occurring in the North Atlantic and *B. Japonica* in the North Pacific, the South Atlantic having *Balæna australis*, and the South Pacific *B. antipodarum* and *B. Novæ-Zealandiæ*.

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[1] According to Ross and many other explorers, great banks of *Laminaria* and other seaweeds, similar to those around Behring Island, on which the *Rhytina* fed, abound in the South Polar seas.

Of the *Pinnipedia*, Seals and Walruses, the Northern Sea Lion, *Otaria Stelleri*, the largest of the genus, ten feet long, from the North Pacific, is represented by *Otaria jubata*, the Patagonian and Southern 'Sea Lion,' and some other corresponding species as *O. Californiana* (California) and *O. ursina*, North Pacific, Prybiloff Island; *O. pusilla*, Cape of Good Hope; *O. Forsteri* and others from Australia. The Walrus (*Trichechus*) is only found in the Arctic seas, North Atlantic, and North Pacific Oceans. The true Seal (*Phoca*) is common to the North Atlantic and the North Pacific coasts, but does not occur in the Southern Ocean.

The 'Sea Leopard,' *Ogmorhinus*, occupies the Antarctic and Southern temperate seas. The Elephant Seal (*Macrorhinus*), or Sea Elephant, the largest of the whole family (twenty feet long), was formerly abundant in the Antarctic seas and also found on the coast of California. The Hon. Walter Rothschild lately obtained one, at great expense, and presented it to the National Museum.

The Penguins (Impennes) may be said to represent in the Southern Ocean the Auks and Divers of the Northern seas.

Whether these are all (as the Penguins and Auks are) merely representative forms, or whether they may have in some cases been able to cross the equatorial region and reach the Arctic from the Antarctic, is an open question. Certain deep-sea water forms of Crustacea may have done so along lines of cold currents in the ocean, but this does not so easily explain the presence of shore and surface-dwelling forms of life having a common facies, if not an actual close family relationship. Still, it must be borne in mind that cold polar currents do reach near to the equator on the South American Chilian coast. The Sea Lions and the Elephant Seal have thus, in all probability, been enabled to "cross the line."

ANTARCTICA IN CONNECTION WITH THE NEIGHBOURING LAND-AREAS.—Fifty years ago there were very few men of science bold enough either to suggest or to accept the theory that the geographical distribution of plants and animals had actually commenced far back in past geological time.

Professor Edward Forbes, S. P. Woodward, Darwin, Wallace, Huxley, Sclater, Blanford, H. O. Forbes, and others have advocated these views, but they have become greatly modified in our own day since the time at which they were first expressed.

Australia was deemed to be a survival from the Jurassic period, New Zealand from the Triassic, and so on.[1] Australia is now known to possess representatives of almost every formation from Cambrian and Silurian times to the Tertiary. The fact remains that the flora and fauna of Australia and New Zealand present remarkable characteristics which, until lately, were believed not to exist on any other part of the earth's surface.

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[1] The great Struthious (wingless) birds of New Zealand were formerly supposed to be the descendants of the makers of the tridactyle footprints left upon the slabs of Triassic sandstone in the Connecticut Valley and elsewhere. These footprints have been described by the late Professor O. C. Marsh, and shown to have been left by bipedal Dinosaurian reptiles, which were living in the Triassic period, before birds had made their appearance.

In favour of a Southern connection of Antarctic Lands.—A. R. Wallace, in "Island Life," says:—"Whenever we find a considerable number of the Mammals [or flightless birds] of two countries that exhibit distinct marks of relationship, we may be sure that an actual land-connection, or a close approach to one, has at one time existed."

Charles Darwin ("Origin of Species," vol. ii, 1888, p. 190), says:—"New Zealand is plainly related to South America, although the next nearest continent is so enormously remote that the fact becomes an anomaly. This difficulty disappears in the view that New Zealand, South America, and the other Southern lands have been stocked in part from the Antarctic Islands, when they were clothed with vegetation during a warmer Tertiary period, before the commencement of the last Glacial epoch."

Dr. W. T. Blanford, F.R.S. (Pres. Geol. Soc., 1890), wrote in his address:—"The biological evidence of a former land connection between South America and Africa is very strong, and if the difficulty about the depth of the intervening ocean is overcome, there is no improbability in the suggestion that, at some period of geological history, an important continent having connections with South America, South Africa, and New Zealand, may have occupied the Antarctic Area."

Professor Huxley, "On the Distribution of Gallinaceous Birds," P.Z.S., 1868, says:—"Of the two sections (the *Alectropodes* and the *Peristeropodes*), the former are restricted to the Northern, and the latter to the Southern Hemisphere." He goes on to compare the Curassows of South America with the Megapodes or Mound-builders of Australia; and he considers that they are sprung from one stock; and that the common ancestors must have developed on some large area in the Southern Hemisphere, from which there was access both to South America and Australia.

It is probable that a very large extent of ancient land around the present Antarctic continent has been lost to us by submergence, and that the rather numerous small islands in the surrounding ocean are but the buoys or landmarks indicating large areas of more or less continuous land, which has since disappeared. This is supported by the many signs of volcanic activity in recent times which these islands display. Doubtless land connections stretched from South America to the South Shetlands, the South Orkneys, South Georgia, and to Kerguelen Island.

Peculiarities of Southern Land-Faunas.—Let us look for a moment at the peculiarities of the Southern land-faunas:—

In no other part of the world do we find such a remarkable assemblage of struthious birds, both of living and extinct forms, distributed over the continents and islands which encircle the Antarctic. In South America we have the *Rhea Americana*. In Africa the Ostrich *Struthio camelus*. In Mauritius we have numerous (8) species of *Æpyornis* (an extinct wingless bird as large as the *Dinornis* of New Zealand), remarkable also from the great size of its eggs. In Mauritius we find the extinct Woodhen *Aphanapteryx*.

In Rodriguez nearly the same form, *Erythromachus*, was also once common. In Australia we have the Emeu and Cassowary living, and the extinct *Dromornis* and *Genyornis*. In New Zealand about twenty species of *Dinornis*, or 'Moa,' the largest attaining a height of at least twelve feet, were once most abundant, and peopled both islands (as the presence of their bones everywhere testifies), but have now been entirely exterminated by the Maoris, as the similar large bird, the *Æpyornis*, was destroyed by the natives in Madagascar. The surviving form is the 'Kiwi' or *Apteryx*, which is also found fossil (*Diaphorapteryx*) in the Chatham Islands 500 miles to the east of Port Lyttelton, New Zealand. *Cabalus*, a flightless Crake, akin to the Woodhens, also survives in the Chatham Islands. This *Cabalus* occurs also on Lord Howe Island, 300 miles off the coast of Eastern Australia to the far north-west of Chatham Island.

Of other flightless birds, we have the *Aptornis defossor*, a large extinct Rail, and Mantell's *Notornis*, recently killed off in New Zealand, a *Porphyrio* also in New Zealand and Norfolk Island.

The Penguins, of which many species are known, occur on the islands and continents of all the Southern lands, just as the Great Auk was at one time distributed around all the circumpolar lands in the Northern Hemisphere, but the Great Auk was not found within the Arctic circle.

AUSTRALIA possesses a peculiar existing fauna belonging to the *Monotremata* and *Marsupialia*. The former: *Ornithorhynchus* and *Echidna* represent the sole surviving forms of the lowest division of the Mammalia, viz. the PROTOTHERIA, and to the order *Monotremata* (egg-laying Mammals), which are confined to Australasia (New Guinea, Australia, and Tasmania). The latter comprising the pouched Mammals, known as the Kangaroos, Wombats, Dasyure, Thylacine, Rat-Kangaroo; *Macropus*, Rock-Wallabies (*Petrogale*), Hare-Wallaby (*Lagorchestes*), *Dorcopsis*, *Dendrologus* (Tree-Kangaroo); *Bettongia*, etc.

Fossil forms are numerous, some like *Diprotodon* and *Nototherium* far exceeding the living forms in size. There are also many other fossil genera, described by Owen, such as *Sthenurus*, *Procoptodon*, *Palorchestes*. In *Diprotodon* the fore and hind limbs are not differentiated, but are of nearly equal length and not adapted for rapid movement. Added to these are the Phalangers, Cuscus, Flying Phalangers; the Koala; and the *extinct Thylacoleo carnifex*, most probably related to the Wombats (*Phascolomys*). Added to these are the Bandicoots (*Perameles*); the Tasmanian Wolf (*Thylacinus*); the Tasmanian Devil (*Dasyurus*); the Pouched Mole (*Notoryctes*); and the Opossums (*Didelphys*), these last being common to America and Australia.

The curious and now almost extinct 'Tuatara' Lizard (*Sphenodon* or *Hatteria*), now confined to an islet off the North Island of New Zealand, formerly existed also in Chatham Islands 500 miles distant by sea.

The most remarkable discovery of late years bearing upon the wide distribution of similar animals over the Southern continents is that of *Miolania*, an extinct genus of land Tortoise, the head of which is ornamented with peculiar bony plates, and the tail is encased in a bony sheath, resembling the tail of *Glyptodon*. The first example of *Miolania* was found in Queensland, Australia; the second on Lord Howe Island, 300 miles to the eastward of the Great Barrier Reef. The third example was lately obtained by Dr. Moreno in Argentina, South America! yet they can only be differentiated specifically, notwithstanding their enormously wide geographical separation from one another.

Amongst the Amphibia the *Cystognathidæ* occur in Australia, Tasmania, and South America. Of fresh-water fishes we have the Southern 'Salmon' *Haplochitonidæ*, and the Southern Pikes *Galaxiidæ*, common to New Zealand, Chili, Patagonia, and the Falkland Islands. Again, the remarkable *Dipnoi* and *Osteoglossi* are peculiar to the rivers of Africa, Australia, and South America, and are unknown north of the equator. *Peripatus* is only known from the West Indies, from South America, South Africa, and Australia. Among the *Scorpionidæ*, the genus *Cercophonius* is only met with in South-East Australia and in South America. *Placostylus*, a genus of land Mollusca, is found in the Solomon Islands, in Fiji, the New Hebrides, Loyalty Island, New Caledonia, Norfolk Island, Lord Howe Island, and in New Zealand.

A summary of the flora characteristic of the Southern Hemisphere fully confirms the conclusions derived from a study of the fauna, and establishes beyond a doubt the former existence of extensive land connections between the Southern continents and islands in Tertiary times which have since disappeared beneath the ocean.

PLANTÆ. SOUTHERN HEMISPHERE (*Notogæa*).—SAXIFRAGEÆ. Of the 'Saxifrages' the genus *Donnatia* occurs in New Zealand, Tasmania, Chili, and Tierra del Fuego. *Escalloniæ*, 17 genera met with in New Caledonia, Australia, and Tasmania. *Cunoniæ*, 18 genera common to New Zealand, Mascarene Islands, South Africa, and South America. Only two out of thirty-five genera cross the equator into the Northern Hemisphere.

PROTEACEÆ. The *Banksias* have 49 genera and 950 species. Only 25 cross the equator. The others belong to Madagascar, Tasmania, New Zealand, and New Caledonia. Some occur fossil in Miocene and Cretaceous Plant-beds in Europe.

MONOMIACEÆ (related to the Laurels), 22 genera and 150 species, have the same distribution as above. One genus, *Laurelia*, is common to Chili and New Zealand.

PERSEACEÆ, the genus *Cryptocarya*, is common to New Zealand, South Africa, and South America.

CONIFERÆ, *Callitris*, is common to Africa, Madagascar, Australia; *Fitzroya* is common to Chili and Tasmania.

PODOCARPEÆ, 3 genera; distributed 1 in Tasmania, 1 in Chili and South America, and 1 South Africa, Australia, and New Zealand.

Todea barbara occurs at the Cape of Good Hope and in Australia.

Lomaria Alpina occurs at the Cape, in Australia, and South America. *Fuchsia* and *Passiflora* are common to New Zealand and

South America. New Zealand and South America have 74 genera of plants in common, 11 identical, and 32 closely allied species.

That earth-movements, on a widely extended scale, have occurred in the South, is evidenced by the very late elevations and subsidences which have taken place in parts of the Andean chain and in Tierra del Fuego, also in Kerguelen Island, Eastern Australia, Tasmania, New Zealand, and the Chatham Islands; whilst the vast upheaval of the Himalayan range itself is only of newer Tertiary age.[1]

P.S.—Those who are interested in following up the suggestions of this Address and inquiring further as to the special members of the fauna and flora of the Southern lands and their inter-relations, will do well to consult Dr. H. O. Forbes' paper read before the Royal Geographical Society, March 13th, 1893, entitled: "The Chatham Islands: their relation to a former Southern Continent" (Supplementary Papers Royal Geographical Society's Journal, vol. iii, part 4, 1893, pp. 607–637), to which the author desires to acknowledge his indebtedness for many interesting facts recorded by him.—H. W.

II.—The Meeting of the Museums Association at Aberdeen, July 14–17, 1903.

The fourteenth annual meeting of this useful body took place during July in Aberdeen, under the presidency of Dr. F. A. Bather. Although the place of meeting was more remote than any yet chosen, the number of members attending was larger than on any previous occasion. The meeting was further noteworthy for the presence of three delegates from foreign museums, while no less than six of the papers read were sent from abroad, also for the fact that a delegate was officially sent from a Government department—the Board of Education.

The work of geological museums, as such, did not receive much attention; but the President was doubtless speaking from experience gained in the Geological Department of the British Museum when he suggested that the time had come to go beyond the hitherto recognised division of public collections into a reserve or study series and an exhibited or public series, and to arrange such collections in three series, namely, (1) for specialists and researchers, not exhibited but kept under lock and key or in private workrooms; (2) for students and collectors, exhibited under glass or in special cabinets open to students, but not elaborately mounted, and accessible only on demand; (3) for the man in the street, selected specimens beautifully mounted so as to make the utmost appeal to the lay public.

Dr. Anton Fritsch, of the Bohemian Museum, Prague, contributed a study of "The Museum Problem in Europe and America," giving to his hearers a number of hints collected during his recent travels. Mr. B. H. Woodward, F.G.S., described "The Western Australian Museum and Art Gallery, Perth," of which he is the energetic curator. Mr. Jeffrey Bell advocated more attention to "Good Form in Natural History Museums," especially as regards harmonious arrangement of cases, colour of background, colour of labels, and the use of technical terms, which, in his opinion, should be avoided in exhibits intended for the public. Professor J. Arthur Thomson urged the need for a faunistic museum for the North of Scotland. Mr. S. S. Buckman, in a paper entitled "Neglect of Opportunities," indicated certain methods by which the relation of biological and geological science to human ideas and needs might be better brought out in the public galleries of natural history museums; in particular he showed how details of palæontology might be relieved of their dryness by being paralleled with the facts of man's individual and social life. These and the other papers which were read will appear *in extenso* and adequately illustrated in the third volume of *The Museums Journal.*

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[1] Dr. Woodward's address was illustrated by about fifty-eight lantern slides, a great number of which were beautifully painted pictures of birds by Keulemans, kindly lent by Dr. H. O. Forbes, Director of the Liverpool Museum, and a series of Arctic views and maps kindly lent by the Royal Geographical Society, besides a number prepared expressly for his address by Dr. H. Woodward.

It was unfortunate that the week chosen for the meeting should have been that when the University authorities were inevitably engaged with the Degree examinations. In spite of much inconvenience to themselves, they kindly admitted members to their picture galleries and scientific museums. The Zoological Collection was described by Professor J. A. Thomson, and the Geological Collection by his assistant, Mr. A. Willard Gibb, M.A. The latter was arranged by the late Professor H. Alleyne Nicholson, LL.D., M.A., F.R.S., F.G.S., to whose memory a medallion portrait with a decorative design in selected Palæozoic fossils, accompanied by a suitable inscription worked out as a repoussé brass tablet, has been placed on the wall of the College Chapel, designed by Miss Alice B. Woodward, and executed by Messrs. Ramsden & Carr of London.

The next annual meeting is to be held in Norwich under the presidency of Dr. S. F. Harmer, F.R.S.

CORRESPONDENCE.

THE BUDLEIGH PEBBLES—MARINE OR FLUVIATILE?

SIR,—In his paper on the Triassic Pebbles of South Devon, Mr. Shrubsole makes a most important statement as to the action of waves on the Budleigh Salterton pebbles. He asserts that "the result [of wave action] is to produce a new deposit altogether, in which the pebbles are usually of a totally different shape. They now become as a rule symmetrical, and lose all trace of angularity" (Q.J.G.S., vol. lix, p. 316). This is diametrically opposed to the following categorical statement of the late Mr. W. Pengelly: "It is worthy of remark, that the pebbles which have performed the modern journey from Budleigh Salterton to Pinney Bay, and those which remain in the bed in the former locality, are identical in form. Re-denudation and a transportation by waves over eighteen miles of rough coast have served only to reduce their dimensions, not to change their shapes; their earlier journey in the Triassic sea had given them the only form of which their structure is capable—a polished oblate spheroid" (Trans. Dev. Assoc., vol. i, pt. 3, p. 53).

The question is absolutely crucial as to whether the Budleigh pebbles are marine or fluviatile.

Pengelly kept the Pebble-bed problem thoroughly in hand, and noticed it in the following papers, viz.: Trans. Dev. Assoc., vol. i, pt. 3, pp. 52-55; vol. ii, p. 37; vol. iv, pp. 197-200; vol. vi, p. 650; and vol. xi, p. 340. Then, in the same Transactions Mr. Ussher had a "Chapter on the Budleigh Pebbles," in 1879, vol. ix, p. 222. This paper is subsequent to the one cited by Mr. Shrubsole.

Since Pengelly's death geologists have nearly boxed the compass as to the derivation of the pebbles. The only bearings remaining unappropriated are those between N. by E. and S.E. by E.

Mr. Shrubsole's observation noted above seems to be by far the most important one made on the Pebble-bed during a generation. If Pengelly is right the pebbles are of marine derivation; if Mr. Shrubsole is right they are not marine, whatever else they may be. But obviously the pebbles may be of marine origin without the present bed having been a beach. Pengelly does not seem to have contended for a beach, and both as a sailor in early life and having spent a long life on the seaboard he was quite familiar with beaches.

It may be noted that Pengelly's interest lay in the quartzites, and it was of these he wrote as being oblate spheroids, and of these alone.

A. R. Hunt.

PRIORITY OF OBSERVATIONS.

Sir,—Mrs. Maria M. Ogilvie Gordon has published in the Trans. Edinb. Geol. Soc., vol. viii, special part—which, by the way, bears no date on the wrapper, but which was received at the British Museum (Nat. Hist.) 13th August, 1903,—a paper on "The Geological Structure of Monzoni and Fassa." I do not propose to notice this paper, as I have not sufficient special knowledge of the district, but merely call attention to a singular statement in the "Prefatory Note."

Mrs. Gordon there says: "I was told that the manuscript of my first paper on Monzoni would be kept in the archives of the Royal Society [the paper was apparently refused publication because an abstract had appeared elsewhere], the scientific priority of my observations dating from its formal *reading on June 19th*, 1902." I beg to inform Mrs. Gordon that she has been entirely misled by her informant. A MS. remains a MS. whether in the hands of the Royal Society or in those of a private person, and the date of reading of a paper in no way constitutes publication. Her MS. on Monzoni, which the Royal Society has 'conveyed,' cannot be quoted, and is perfectly useless so far as geology is concerned. Such confiscation of manuscripts is a very serious injustice, not merely to authors, but also to others working on the subject, and is indefensible.

C. Davies Sherborn.

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ORIGINAL ARTICLES.

I.—The Functions of Geology in Education and Practical Life.

By Professor W. W. Watts, M.A., M.Sc., etc., etc., President of the Geological Section.[1]

AT the Leeds Meeting of the British Association in 1890, my old friend Professor A. H. Green delivered an address to the Section which has generally been regarded as expressing an opinion adverse to the use of the science of geology as an educational agent. Some of the expressions used by him, if taken alone, certainly seem to bear out this interpretation. For instance, he says: "Geologists are in danger of becoming loose reasoners"; further he says: "I cannot shut my eyes to the fact that when geology is to be used as a means of education there are certain attendant risks that need to be carefully and watchfully guarded against." Then he adds: "Inferences based on such incomplete and shaky foundations must necessarily be largely hypothetical."

Such expressions, falling from an accomplished mathematician and one who was such an eminent field geologist as Professor Green, the author of some of the most trustworthy and most useful of the Geological Survey memoirs, and above all one of the clearest of our teachers and the writer of the best and most eminently practical textbook on physical geology in this or any other language, naturally exercised great influence on contemporary thought. And I should be as unwise as I am certainly rash in endeavouring to controvert them but for the fact that I think he only half believed his own words. He remarks that "to be forewarned is a proverbial safeguard, and those who are alive to a danger will cast about for a means of guarding against it. And there are many ways of neutralising whatever there may be potentially harmful in the use of geology for educational ends."

After thus himself answering what is in reality his main indictment, Professor Green proceeds with the rest of an address crammed full of such valuable hints as could only fall from an experienced and practical teacher, showing how much could be done if the science were only properly taught.

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[1] British Association for the Advancement of Science, Southport, Sept. 9-16, 1903. Address to the Geological Section.

And then he concludes by asking for "that kindly and genial criticism with which the brotherhood of the hammer are wont to welcome attempts to strengthen the corner-stones and widen the domain of the science we love so well."

I think the time has now come to speak with greater confidence, and, although the distant signal stands at danger, to forge ahead slowly but surely, keeping our eyes open for all the risks of the road, with one hand on the brakes and the other on the driving gear, secure at least in the confidence that Nature, unlike man, never switches a down train on to the up track.

Those of us who have been teaching our science for any considerable time have come to realise that there are many reasons why geology should be more widely taught than at present; that there are many types of mind to whom this science appeals as no other one does; and that there are abundant places and frequent circumstances which allow of the teaching of it when other sciences are unsuitable.

To begin with, there is no science in which the materials for elementary teaching are so common, so cheap, and everywhere so accessible. Nor is there any science which touches so quickly the earliest and most elementary interests. It was for this reason that Huxley built his new science of physiography on a geological basis. Hills, plains, valleys, crags, quarries, cuttings, are attractive to every boy and girl, and always rouse intelligent curiosity and frequent inquiry; and although the questions asked are difficult to answer in full, a keen teacher can soon set his children to hunt for fossils or structures which will give them part of the information they seek. Of course the teaching cannot go very far without simple laboratory and museum accommodation, and without a small expenditure on maps and sections; but the former of these requirements can soon be supplied from the chemical laboratory and by the collection of the students themselves, while the latter are every day becoming cheaper and more accessible and useful. The bicycle and the camera, too, are providing new teaching material and methods, while at the same time they are giving new interests. The bicycle has already begun to create a generation to whom relief maps are not an altogether sealed book, and for whom the laws which govern the relief of a country are rapidly finding practical utility; and the camera, at the same time that it quickens the appreciation of natural beauty, must give new interest to each scrap of knowledge as to the causes, whether botanical or geological, to which that beauty is due. And it is this new knowledge which in turn develops the æsthetic sense. *Mente, manu, et malleo* sums up most of what is required in the early stages of learning; but to round off the motto we still require words to express the camera and bicycle.

ıer reason is the open-airness of the practice of the science. light of the open country comes with intense relief after ısroom, the laboratory, or the workshop. In education ly, and especially in geological education, we have reached of the period when

> "All roads lead to Rome
> Or books—the refuge of the destitute."

rse, I realise fully the vital necessity of laboratory and ı work in the stages of both learning and investigation, and eely admit that there is an immense amount of useful work .one and to be done in these institutions alone. But what I do right to insist upon is that all work in the laboratory seum must be mainly preparatory to the field-work which low; every type of geological student must be sent into the ›oner or later, and in most cases the sooner the better. generally found that students in the early stages have a great ınce to the grind of working through countless varieties of s, rocks, and fossils; but once they have gone into the field, d with their own hands, and seen the importance of these and the inferences to be drawn from them, for themselves—deed they have got keen—they come back willingly, even , to any amount of hard indoor work.

t is when they leave ordinary excursion work and start upon field training that one really feels them spurt forward. As they begin to realise that surface-features are only the reflex -structure and can be utilised for mapping, that to check ıes and initiate new ones they must search for and find new 'es, and that each observation, while settling perhaps one l point, may originate a host of new ones, when, above all, ı be trusted with a certain amount of individual responsibility 'en a definite point to settle for themselves, it is then that ogress is most rapid, and is bounded only by their powers of ıce.

'e often watched my students through the various stages of eld training with the deepest interest as a study of the ›ment of character. At first they look upon it merely as from the tedium of the classroom and laboratory, and as ant country excursion. But gradually the fascination of ı comes over them, and as they feel their capacity increasing ir grip and insight into the structure of the country deepening, see them growing up under one's eyes. They come into the 'abble of larky boys; they begin to develop into men before ıve it.

what is true of students is more than ever true of the working ıt. I hold that every geologist, whatever his special branch , should spend a portion of every year in the field. Though logist may have specimens sent to him from every variety, e common ones, in a rock-mass, and have their relations and ions properly explained to him, it is quite impossible for him to feel and appreciate these proportions and relationships so well as if he had studied and collected in the field and gained a personal interest in them. Besides this the conclusions drawn in the field are the crystalline and washed residuum, so to speak, left on the mind after the handling of dozens of specimens, weathered and unweathered, and the seeing them in a host of different lights and aspects. The rock is hammered and puzzled over and its relations studied, until some conclusion is arrived at which bears the test of application to all the facts observed in the field.

Again, once a palæontologist is divorced from the field he loses the significance of minute time variations, the proportion of aberrant to normal forms, and the value of naked-eye characteristics which can be 'spotted' in the field. Huxley once asked for a palæontologist who was no geologist; I venture to think we have now had enough of them. What we want above all at the present time is the recognition of such characters as have enabled our field palæontologists to zone by means of the graptolites, the ammonites, and the echinids, so that every rock system we possess may be subdivided with the same minuteness and reliability as the Ordovician, Silurian, and Jurassic systems, and the Chalk.

If this is once done the biological results will take care of themselves, and we may feel perfect confidence that new laws of biological succession and evolution will result from such work, as indeed they are now doing—laws which could never be reached from first principles, but could only come out in the hands of those to whom time and place were the factors by which they were most impressed. It is only by field-work that we shall ever get rid of the confusion which has been inevitable from the supposed existence of such so-called species as *Orthis caligramma, Atrypa reticularis,* and *Productus giganteus.*

As for the geological results, it is only necessary to read the excellent and workmanlike Address delivered to this Section at Liverpool in 1896 by Mr. Marr to realise how many problems of succession and structure, of distribution and causation, of ancient geography and modern landscape, are still awaiting solution by the application of minute and exact zonal researches.

On the other hand it goes without saying that the more a field geologist knows of his rocks and fossils the better will his stratigraphical work become; but this is too obvious to require more than stating.

Geology, again, is of value as a recreative science, one which can be enjoyed when cycling, walking, or climbing, even when sailing or travelling by rail. Indeed, it is difficult to find a place in which to treat the confirmed geologist if you wish to make him a 'total abstainer.' There are others than those who must make use of their science in their professions, those in need of a hobby, those interested in natural scenery, veterans who have seen much and now have leisure and means to see more, and those fortunate ones who have not to earn their bread by the sweat of their brain or brow. Many of these have done and are doing good work for us, and many more would find real pleasure in doing so if only they had been inoculated in those early days when impressions sink deep. Mr. A. S. Reid, who has had much and fruitful experience in teaching, tells me that he has often seen seed planted in barren ground at school spring up and grow and blossom as a country holiday recreation after schooldays, or bear the good fruit of solid research after lying dormant for many years.

We may next look upon geology as an educational medium from quite a different point of view. If more than half the work of the man of science is the collection of fact, and of actual fact as opposed to the result of the personal equation, geology is perhaps the very best training-ground. There are such hosts of facts to be still recorded, so many erroneous observations to be corrected, and so much hope of extending observations on already recorded facts, that there is plenty of work even for the man who can snatch but limited leisure from other pursuits and the one who is a collector of fact and nothing else, as well as those

"Under whose command
Is earth and earth's, and in their hand
Is Nature like an open book."

But in the collection of facts a wise and careful selection is constantly necessary in order to pick out from the multitude those which are of exceptional value and importance in the construction of hypotheses. Nature, it is true, cannot lie; she is a perfectly honest but expert witness, and it takes an astonishing amount of acute cross-examination to elicit the truth, the whole truth, and nothing but the truth.

There is no science which needs such a variety of observations as field geology. When we remember that Sedgwick and Darwin visited Cwm Glas and carried away no recollection of the features which now shout 'glaciation' to everyone who enters the Cwm, it is easy to see how alert must be the eyes and how agile the mind of the man who has to carry a dozen problems in his mind at once, and must be on the look-out for evidence with regard to all of them if he would work out the structure of a difficult country; and who is not only looking out for facts to test his own hypothesis, but wishes to observe so accurately that if his hypothesis gives way even at the eleventh hour his facts are ready to suggest and test its successor. There is no class of men so well up in what may be called observational natural history generally as the practised field geologist, because he never knows at what moment some chance observation—a mound, a spring, a flower, a feature, even a rabbit-hole or a shadow—may be of service to him. Not only should he know his country in its every feature and every aspect, but he must have, and in most cases soon acquires, that remarkable instinct which can only be denoted as an 'eye for a country,' with which generally goes a naturalist's knowledge of its plants and of its birds, beasts, and fishes.

At the present time many educationists are in favour of teaching only the experimental sciences, to the exclusion of those which collect their facts by observation. This attitude may do some good to geology in compelling us to pay more attention to that side of our science which has been better cultivated hitherto in France than in our own country. But whether we think of education as the equipping of a scientific man for his future career or as the training of the mind to encounter the problems of life, we must admit that it would be as wrong to ignore one of the two ways only of collecting fact as it would be to teach deductive reasoning to the exclusion of that by induction. Indeed, this is understating the case, for in the vast majority of the problems which confront us in every-day life the solution can only be reached if an accurate grasp of the facts can be obtained from observation. The training of the mind solely by means of experiments carefully designed to eliminate all confusing and collateral elements savours too much of 'milk for babes' and too little of 'strong meat for men.'

Mr. Teall, in his masterly address to the Geological Society in 1901, pointed out "that the state of advancement of a science must be measured, not by the number of facts collected, but by the number of facts *co-ordinated.*" Theory, consistent, comprehensive, tested, verified, is the lifeblood of our science as of any other. It is what history is to politics, what morals are to manners, and what faith is to religion.

It is almost impossible to collect facts at all without carrying a working hypothesis to string them on. It is easy to follow Darwin's advice and speculate freely; the speculation may be right, and if wrong it will be weeded out by new facts and criticism, while the speculative instinct will suggest others. In hypothesis there will always be an ultimate survival of the fittest.

And it is not only easy but absolutely necessary, because in geology, more perhaps than in any other science, hypotheses are like steps in a staircase: each one must be mounted before the next one can be reached; and if you have no intention of coming back again that way, it does not matter if you destroy each step when you have made use of it. Every new hypothesis has something fresh to teach, and nearly all have some element of untruth to be ultimately eliminated. But each one is a stage, and a necessary stage, in progress.

In physics and in chemistry the chief difficulties are those which surround the making of experiments. When these have been successfully overcome the right theory follows naturally, and verification is not usually a very lengthy process. In geology, on the other hand, theory is more quickly arrived at from the numerous facts; but the price is paid in the patience required for testing and the ruthless refusal to strain fact to fit theory. Every hypothesis leads back to facts again and again for verification, extension, and improvement.

Many of the leading conclusions of our science have not yet become part of the common stock of the knowledge of the world; indeed, they are not even fully realised by many men eminent in their own sciences. The momentum given by Werner and Playfair, Phillips and Jukes, Sedgwick and Lyell, and other pioneers of the fighting science, has died down, and in the interval of hard work, detailed observation, minute subdivision, involved classification, and pedantic nomenclature which has followed, and which I believe to be only the prelude to an epoch of more important generalisation in the immediate future, it has been difficult for an outsider to see the wood for the trees. He has hardly yet realised that facts as vital to the social and economic well-being of the people at large, and conclusions of as great importance in the progress of the science and of as far-reaching consequence in the allied sciences, are being wrung from Nature now as in the past.

"The unimaginable touch of Time," the antiquity of the globe as the abode of life, the absolute proof of the evolution of life given by fossils, the proofs of change and evolution in geography and climate, the antiquity of man, the nature of the earth's interior, the tremendous cumulative effect of small causes, the definite position of deposits of economic value, the rôle played by denudation and earth-movement in the development of landscape, the view of the earth as a living organism with the heyday of its youth, its maturity, and its future old age and death, to mention but a few of our great principles, furnish us with conceptions which cannot fail to quicken the attention and inspire the thought of students of history, geography, and other sciences.

Now that these things are capable of definite proof, that they are of real significance in the cognate sciences, and of actual economic value, above all now that the nineteenth century, the geological century, has closed, that the heroic age is over, that we have passed the stages of scepticism and religious intolerance and reached the stage "when everybody knew it before," it might be expected that a fairly accurate knowledge and appreciation of these principles should form part of the common stock of knowledge, and be a starting-point in the teaching of allied sciences.

Another feature which adds to the attractiveness of geological observations is their immediate usefulness from many points of view. The relief and outline of any area is as closely related to its rocky framework as the form of a human being is related to his skeleton and muscles. The geological surveyor recognises how every rise and fall is the direct reflex of some corresponding difference in the underlying rocks; he seeks to observe and explain the ordinary as well as anomalous ground features, every one of which conveys some meaning to him.

A geological basis for the classification and grouping of surface-features is the only one which is likely to be satisfactory in the end, because it is the only one founded on a definite natural principle, the relation of cause to effect. It is not without good reason that the topographic and geological surveys of the United States are combined under one management, and nowhere else are the topographic results more accurate and satisfactory. Landscape is traced back to its ultimate source, and consequently sketched in with more feeling for the country and greater accuracy of knowledge than would otherwise be possible. Geologists were among the first to cry out for increasing accuracy and detail in our Government maps, and they have consistently made the utmost use of the best of these maps as fast as they appeared. With the publication of each type of map, hachured, contoured, six-inch, twenty-five inch, the value and accuracy of geological mapping have advanced step by step. Wherever the topography is better delineated than usual the facilities are greater for accurate geological work, and the best geological maps, and those in greatest demand, are always those based on the most minute and detailed topographic work. On the other hand, geologists are training up a class of men who can read and interpret the inner meaning of these maps, and make the fullest use of the splendid facilities given by the minute accuracy of the ordnance work.

Lord Roberts has recently complained that the cadets at Woolwich are unable to read and interpret maps, and he "strongly advised them to set about improving themselves in this respect, or they would find themselves heavily handicapped in the future." I believe that the only training in this subject before entering the Royal Military Academy and the Royal Military College has been that given to those candidates who have taken up geology for their entrance examination. By encouraging these students to study and draw maps and sections of their own districts, and to explain and draw sections across geological maps generally, thus accounting for surface-features, the examiners have compelled this small group of candidates to see deeper into a map than ordinary people. If only this training had been encouraged and advanced and made use of later, the Commander-in-Chief would have had no cause of complaint with regard to these particular men. Looking at a map is one thing; working at it, seeing into it, and getting out of it what is wanted from the vast mass of information crammed into it, is quite another; and geology is the very best and perhaps the only means of compelling such a close study of maps as to enable students to seize upon the salient features of a country from a map as quickly and accurately as if the country itself were spread out before them. The geologist is compelled to work out and classify for himself the features he observes on his maps, such as scarps and terraces, crags and waterfalls, streams and gorges, passes and ridges, the run of the roads, canals, and railways, the nature and accessibility of the coast, and all those features which make the difference between an easy-going and a difficult country. When he has worked his way over a map in this fashion that map becomes to him a real and telling picture of the country itself.

Experience, bitter experience, in South Africa has shown the necessity not only for good maps and map-reading, but for that which is the most priceless possession alike of the best field geologists and of the best strategists, a good 'eye for a country.' It has been said that the Boer war was a geographical war; but it was even more, and, especially in its later stages, a topographic war. Again and again the Boers aroused our astonishment and admiration by the way in which their topographic knowledge and instinct enabled them to fight, to defend themselves, and to secure their retreat by the most consummate ability in utilising the natural features of their country. This was due to two things. In the first place they took care to have with them in each part of the country the men who knew that particular district best in every detail and in every aspect. But in the second place there can be no doubt that they made the utmost use of that hunter-craft by which the majority of them could take in at a glance the character of a country, even a new one, as a whole, guided by certain unconscious principles which each man absorbed as part of his country life and hunter's training. They possessed, and had of necessity cultivated to a very high degree, an 'eye for a country.'

Now the study of the geology of any district, and especially the geological mapping of it, goes a long way towards giving and educating the very kind of eye for a country which is required, partly by reason of the practice in observation and interpretation which it is continuously giving, and partly because it deliberately supplies the very kinds of classification and the principles of form which a hunter-people have unconsciously built up from their outdoor experience.

Any geologist who thinks of the Weald, the wolds and downs of Eastern England, the scarps and terraces of the Pennine, the buried mountain structure of the Midlands, even the complicated mountain-types of Lakeland and Wales, will remember how often his general knowledge of the rock-structure of the region has helped him as a guide to the topography; and as his geological knowledge of the area has increased he will recall how easy it has become to carry the most complicated topography in his mind, or to revive his recollection of it from a glance at the map, because the geological structure, the anatomy, is present in his mind throughout, and the outside form is the inevitable consequence of that structure. Indeed, the reading of a good geological map to the geologist is like the reading of score by a musician.

Surely it would be most unwise if the Committee on Military Education were to cut out of their curriculum the one subject which has exercised and educated this faculty, and one which is at the same time doing a great deal to counteract that degeneration of observing faculties inseparable from a town life. Some cadets at least ought to be chosen from amongst those men who have been trained by this method to see quickly and accurately into the topographic character and possibilities of a country, and provision should be made for educating their faculties further until they become of genuine strategic value.

Then I believe it would be correct to say that no class of men get to know their own country with anything like the minuteness and accuracy of the geological surveyor. The mere topographer simply transfers his impressions on the spot as quickly as may be to paper, and has no further concern with them. The geologist must keep them stored in his mind, watching the variation and development of each feature from point to point for his own purposes. He must traverse every inch of his ground, he must know where he can climb each mountain and ford every brook, where there are quarries or roads, springs or flats; what can be seen from every point of view, how the habitability or habitations vary from point to point; in short, he must become a veritable walking map of his own district. Why not scatter such men in every quarter of the globe, particularly where any trouble is likely to arise? They are cheap enough, they will waste no time, and they will be so glad of the chance for research that they will not be hard to satisfy in the matter of pay and equipment. Thus you will acquire a corps of guides, ready wherever and whenever they are wanted; and when trouble arises they may do a great deal by means of their minute knowledge of topography to save millions of money and thousands of lives, and to prevent the irritating recurrence of the kind of disaster with which we have become sadly familiar within the last five years.

In dealing with the relationship of geology to geography, geologists are frequently charged with claiming too much. On this point at least, however, there can be no difference of opinion, that the majority of geological surveyors and unofficial investigators have kept their eyes open to this relationship, and have often contributed new explanations to old problems. They have been compelled to observe, and often to explain, surface-features before making use of them in their own mapping, and in doing so have often hit upon new principles. It is hardly needful to mention such examples as Ramsay's great conception of plains of marine denudation, Whitaker's convincing memoir on subaërial denudation, Jukes's explanation of the laws of river adjustment, Gilbert's scientific essay on erosion, Heim's demonstration of the share taken by earth-movement in the modelling of landscape features, and the exceedingly valuable proofs of the relation of human settlement and movement to underground structure, worked out with such skill and diligence by Topley in his masterly memoir on the Weald—the jumping-off place, if I may so term it, of the new geography.

No one is more pleased than geologists that geographers have ceased to draw their knowledge of causation solely from history, and that they have turned their attention to the dependence and reaction of mankind on nature as well. But while hoping that geographers will continue to study, so far as they logically can, the relationshipof plants, animals, and mankind to the solid framework of the globe on which they live, we must draw the line at the invention of new geological hypotheses to explain geographic difficulties on no better evidence than that furnished by the difficulties themselves; on the other hand, we must insist that each new geological principle must take its place amongst geographic explanations as soon as it is freely admitted to be based on a sound substratum of fact.

I must confine myself to a few instances of what I mean. Mr. Marr's geological work on the origin of lake-basins has led to some remarkable and unexpected conclusions with regard to the history and origin of the drainage of the Lake district. Some of the very difficult questions raised by the physical geography of the North Riding of Yorkshire have received a new explanation from the researches of Mr. Percy F. Kendall and Mr. A. R. Dwerryhouse, an explanation which is the outcome of purely geological methods of observation of geological materials. Again, the simple geological interpretation of a well-known unconformity between Archæan and Triassic rocks has made it extremely probable that many of the present landscapes, not only in the Midlands but elsewhere, may be really fossil landscapes, of great antiquity and due to causes quite different from those in operation there at the present day. In mountain regions, too, it can only be by geological observation that we shall ever determine what has been the precise direct share of earth-movement in the production of surface-relief. Such examples seem to indicate that many of the principles must be of geological origin but of geographic application.

While geology has been of direct scientific utility in topography and geography there is another domain, that of economic geology, which is entirely its own. The application of geology extends to every industry and occupation which has to do with our connection with the earth on which we live. Agriculture, engineering, the obtaining of the useful and precious metals, chemical substances, building materials, and road metals, sanitary science, the winning and working of coal, iron, oil, gas, and water, all these and many more pursuits are carried on the better if founded on a knowledge of the structure of the earth's crust. Indeed, a geological map of this country, showing rocks, solid and superficial, of which no economic use could be made, would be nearly blank. Yet so much has this side of the science been neglected of recent years that our only comprehensive textbooks on it are altogether out of date.

But in teaching geology as a technical science, or rather as one with technological applications, one of the greatest difficulties before us is to steer between two opposing schools, the so-called theoretical school and the practical school.

There are those who say there is but one geology, the theoretical, and that a thorough knowledge of this must be obtained by all those who intend to apply the science. Others think that this is too much to ask—that the time available is not sufficient—and that it is only necessary to teach so much of the subject as is obviously germane to the question in hand.

The best course appears to me to be the middle one between the two extremes. If the engineer or miner, the water-finder or quarryman, has no knowledge of principles, but only of such facts as appear to be required in the present position of his profession, he will be incapable of making any improvement in his methods, so far as they depend upon geology. If, on the other hand, he is a purely theoretical man without a detailed practical and working acquaintance with the facts which specially concern him, he will be put down by his colleagues as unpractical; he will have to learn the facts as quickly as he can, and buy his experience in the dearest market.

It seems to me that there is certain common ground which must be acquired by all types of professional men. The general petrographic character of the common rocks, enough of their mode of origin to aid the memory, the principle of order and age in the stratified rocks, the use of fossils and superposition as tests of age, the nature of unconformities, the relation of structure to the form of the ground, the occurrence of folds and faults, and above all the reading of maps and sections, and sufficient field-work to give confidence in the representation of facts on maps—these things are required by everybody who makes any use of geology in his daily life.

But when so much has been acquired it should be possible to separate out the students for more special treatment. The coal-miner will require especially a full knowledge of the coal-bearing systems, not in our own islands merely, but all over the world; a special acquaintance with the effects of folds and faults, and an advanced training in the maps and sections of coal-bearing areas. The vein-miner should be well up in faulting and all the geometrical problems associated with it, and he should have an exhaustive acquaintance with the vein and metalliferous minerals.

The water engineer needs to know especially well the porous and impervious rock types, the texture and composition of these rocks, the nature of their cements and joints, and the distribution of water-levels in them. Further, he must know what there is to be known on the problems of permeability and absorption, the relation of rain to supply, the changes undergone by water and the paths taken by it on its route underground, and the varying nature of rocks in depth. He must also realise the effects of folds and faults on drainage areas and on underground watercourses, the special qualities of water-yielding rocks, of those forming the foundation of reservoir sites, and those suitable for the construction of dams.

The sanitary engineer will need to be acquainted with the same range of special knowledge as the water engineer, but will naturally be more interested in getting rid of surface water without contaminating it more than he can help than in obtaining it; he will also need a more detailed acquaintance with superficial deposits than any other class of professional men.

The quarryman and architect ought to know the rocks both macroscopically and microscopically, in their chemical and mineralogical character, their grains and their cements. But he ought to be well acquainted with the laws of bedding, jointing, and cleavage, with questions of outcrop and underground extent, and all those her characters which make the difference between good and bad one, or between one desirable and undesirable in the particular rcumstances in which a building is to be erected. Further, he ould make a particular study of the action of weight and weather the rocks which he employs.

The road engineer and surveyor, now that it has been discovered at it is cheaper and better to use the best and most lasting road-etal instead of any that happens to be at hand, requires to have an tensive acquaintance with our igneous and other durable rocks. e needs, however, not only petrographic and chemical knowledge, it also a type of information not at present accessible in England, e relative value of these rocks in resisting the wear and tear of affic, the cementing power of the worn material, and the surface aracters of roads made from them, in order that he may in each se select the stone which in his particular circumstances gives the st value for money. It would surely pay the County Councils follow, with modifications, the example of the French and mericans, and carry out a deliberate and well-planned series of periments on all the material accessible to them in their respective stricts.

The teaching of the application of geology should therefore take me such form as the following:—First, the principles should be oroughly taught with the use for the most part of examples drawn om the economic side; thus cementing might be illustrated on the de of water percolation, jointing from the making of mine roads and om quarry sites, faulting from effects on coal outcrops and veins, conformity from its significance to the coal-miner; while in aching the sequence of stratified rocks the systems and stages uld be mainly individualised by their economic characters. When is is done the class must be divided into groups, each paying ecial attention to the points which are of essential importance them.

The teaching at all stages should be practical and, so far as can , experimental, and in all cases where possible a certain amount field-work should be attempted. For the field, after all, is the boratory of the geologist, where he can observe experiments being ade on a gigantic scale under his eyes.

The aim of the teaching should be to give to students the uipment necessary to deal with the chief geological problems at they will meet with in their varied professions; it should show em where to go for maps, memoirs, or descriptions of the areas ith which they are dealing; and in cases of great difficulty should able them to see where further geological assistance is required, d to weigh and balance the expert evidence given them against e economic and other factors of the problem before them.

From men educated thus geology has the right to expect valuable return. There is a vast amount of knowledge on onomic subjects in existence but not readily accessible. It has en obtained by experts, and after being used is locked up or lost. nd yet it is the very kind of knowledge which is wanted to extend our principles further into the economic side of the subject. So well is this recognised that many geologists are attracted to economic work mainly because of the wide range of new facts that they can only thus become acquainted with. It is possible to make use of many of these facts for scientific induction without in any way betraying confidence or revealing the source from which they are obtained; and even if they cannot be used directly they are often of great service in giving moral support, or the contrary, to working hypotheses founded on other evidence.

The knowledge of our mineral resources is of such vital consequence to ourselves and to our present and future welfare as a nation, and yet it is a matter of so much popular misconception, that I feel bound to dwell on this subject a little longer. To anyone who studies the growth and distribution of population in any important modern State the facts and reasons become as clear as day.

It is easy to construct maps showing at a glance the density of population in any country. Perhaps the most effective way to do so is to draw a series of isodemic lines, and to gradually increase the depth of tint within them as the number of people per square mile increases until absolute blackness represents, say, over 2,000 people per square mile. Such maps are the best means of displaying the geography of the available sources of energy in a country at any particular period. Population maps of England and Wales in the early part of the eighteenth century would be pale in tint with a few rather darker patches, and would show a distribution dependent solely upon food as a source of energy working through the medium of mankind and animals. Such maps would be purely agricultural and maricultural, dependent upon the harvests of the land and sea. Maps made at a later period would show a new concentration round other sources of energy, particularly wind and water, but would not be perceptibly darker in tint as a whole; for although we are apt to think that we have in this country too much wind and water, they are not in such a form that we can extract any appreciable supply of energy directly from them.

But maps representing the present population, while still mainly energy maps, at once bring out the fact that our leading source of energy is now *coal*, and no longer food, wind, or water. The new concentrations, marked now by patches and bands of deepest black, have shifted away from the agricultural regions and settled upon and around the coalfields. The map has now become geological.

The difference between the old and the new map is, however, not only in kind; it is even more remarkable in degree. The population is everywhere much denser. Not only are the mining and manufacturing areas on the new map more than eight times as densely populated as any areas on the older map, not only is the average population five times greater throughout the country, but the lightest spot in the new map is nearly as dark as the darkest spot on the old one. The sparsest population at the present day is as thick on the ground as it was in the densest spots indicated on the older map, while at the same time the standards of wages, living, and comfort, instead of decreasing, have increased.

The discovery of this new source of energy, coal, immediately gave employment to a much larger number of people; it paid for their food and provided the means of transporting it from the uttermost parts of the earth. Under agricultural conditions the map shows that the population attained a given maximum density, and no further increase was possible, the density being regulated by the food supply raised on the surface of the land. Our dwelling-house was but one story high. Under industrial conditions our mineral resources can support five times the number. Our dwelling-house is of five stories—one above ground and four below it.

At the same time the type of distribution is altered. The agricultural areas are now covered by a relatively scanty population and the dense areas are situated on or near to the coal and iron fields, the regions yielding other metals, those suitable for industries which consume large supplies of fuel, and a host of new distributing centres, nodal points on the new lines of traffic, either inside the country or on its margins where the great routes of ocean transport converge, or where the sea penetrates far in towards the industrial regions.

It has been the good fortune of this country to be the first to realise, and with characteristic energy to take advantage of, the new possibilities for development opened up by the discovery and utilisation of its mineral wealth. We were exceedingly fortunate in having so much of this wealth at hand, easy to get and work from geological considerations, cheap to transport and export from geographical considerations. So we were able to pay cash for the products of the whole world, to handle, manufacture, and transport them, and thus to become the traders and carriers of the world.

But other nations are waking up. We have no monopoly of underground wealth, and day by day we are feeling the competition of their awakening strength. Can we carry on the struggle and maintain the lead we have gained?

In answering this question there are three great considerations to keep in mind. First, our own mineral wealth is unexhausted; secondly, that of our colonies is as yet almost untouched; and thirdly, there are still many uncolonised areas left in the world.

The very plenty of our coal and iron, and the ease of extracting it, has been an economic danger. There has been waste in exploration because of ignorance of the structure and position of the coal-yielding rocks; waste in extraction because of defective appliances, of the working only of the best-paying seams and areas, of the water difficulty, and the want of well-kept plans and records of areas worked and unworked; waste in employment because of the low efficiency of the machinery which turns this energy into work. With all this waste our coalfields have hardly yielded a miserable *one* per cent. of the energy which the coal actually possesses when *in situ.*

Engineers and miners are trying to diminish two of these sources of waste, and geology has done something to reduce that of exploration. This has been done by detailed mapping and study, so that we now know the areas covered by the coal-seams, their varying thickness, the 'wants,' folds, and faults by which they are traversed, and all that great group of characters designated as the geological structure of the coalfields. It could not have been accomplished unless unproductive as well as productive areas had been studied, the margins of the fields mapped as well as their interiors, and unless the geological principles wrested from all sorts of rocks and regions had been available for application to the coal districts in question. We no longer imagine every grey shale to be an index of coal; we are not frightened by every roll or fault we meet with underground; nor do we, as in the past, throw away vast sums of money in sinking for coal in Cambrian or Silurian rocks.

We cannot afford, hard bitten as we are in the rough school of experience and with our increased knowledge, to make all the old mistakes over again, and yet we are on the very eve of doing it. Up to the present it is our visible coalfields that we have been working, and we have got to know their extent and character fairly well. But so much coal has now been raised, so much wasted in extraction, and so many areas rendered dangerous or impossible to work, that we cannot shut our eyes to the grave fact that these visible fields are rapidly approaching exhaustion. The Government have done well to take stock again of our coal supply, and to make a really serious attempt by means of a Royal Commission to gauge its extent and duration; and we all look forward to that Commission to direct attention to this serious waste, and to the possibility of better economy which will result from the fuller application of scientific method to exploration, working, and employment.

But we still have an area of concealed coalfields left, possibly at least as large and productive as those already explored and as full of hope for increased industrial development. It is to these we must now turn attention with a view of obtaining from them the maximum amount possible of the energy that they contain. The same problems which beset the earlier explorers of the visible coalfields will again be present with us in our new task, and there will be in addition a host of new ones, even more difficult and costly, to solve. In spite of this the task will have to be undertaken, and we must not rest until we have as good a knowledge of the concealed coalfields as we have of those at the surface. This knowledge will have to be obtained in the old way by geological surveying and mapping, and by the co-ordination of all the observations available in the productive rocks themselves and in those associated with them, whether made in the course of geological study or in mining and exploration. But now the work will have to be done at a depth of thousands instead of hundreds of feet, and under a thick cover of newer strata resting unconformably on those we wish to pierce and work. When we get under the unconformable cover we meet the same geology and the same laws of stratigraphy and structure as in more superficial deposits, but accurate induction is rendered increasingly difficult by the paucity of exposures and the small number of facts available owing to the great expense of deep boring. How precious, then, becomes every scrap of information obtained from sinkings and borings, not only where success is met with, but where it is not; and how little short of criminal is it that there should be the probability that much of this information is being and will be irretrievably lost!

Mr. Harmer pointed out in a paper to this Section in 1895 that under present conditions there was an automatic check on all explorations of this kind. The only person who can carry it out is the landowner. If he fails he loses his money and does not even secure the sympathy of his neighbours. If he succeeds his neighbours stand to gain as much as he does without sharing in the expense. The successful explorer naturally conceals the information he has acquired, because he has had to pay so heavily for it that he cannot afford to put his neighbours in as good a position as himself and make them his rivals as well; while the unsuccessful man is only too glad to forget as soon as possible all about his unfortunate venture. And yet in work of this kind failure is second only to success in the value of the information it gives as to the underground structure which it is so necessary to have if deep mining is to become a real addition to the resources of the country.

Systematic and detailed exploration, guided by scientific principles, and advancing from the known to the unknown, ought to be our next move forward: a method of exploration which shall benefit the nation as well as the individual, a careful record of everything done, a body of men who shall interpret and map the facts as they are acquired and draw conclusions with regard to structure and position from them—in short, a Geological Survey which shall do as much for Hypogean geology as existing surveys have done for Epigean geology, is now our crying need. Unless something of this sort is done, and done in a systematic and masterful manner, we run a great risk of frittering away the most important of our national resources left to us, of destroying confidence, of wasting time and money at a most precious and critical period of our history, and of slipping downhill at a time when our equipment and resources are ready to enable us to stride forward.

Even supposing the scheme outlined by Mr. Harmer cannot be carried out in its complete form, a great deal will be done if mining engineers can receive a sufficient geological training to enable them to realise the significance of these underground problems, so that they can recognise when any exploration they are carrying out inside their own area is likely to be of far-reaching geological and economic significance outside the immediate district in which they are personally and immediately concerned.

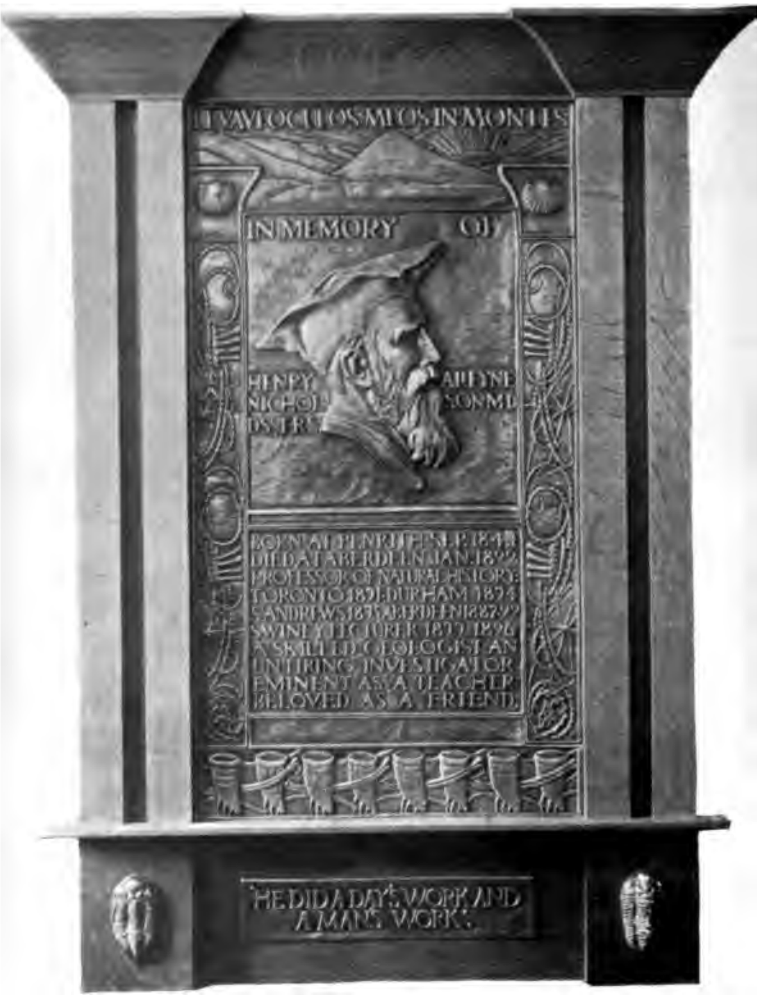
Turning to our colonies, it is true that in many of them much is being done by competent surveys to attain a knowledge of mineral resources, but this work should be pushed forward more rapidly, with greater strength and larger staffs, and above all it should not be limited to areas that happen to be of known economic value just at the present moment. It is almost a truism that the scientific principle of to-day is the economic instrument of to-morrow, and it will be a good investment to enlarge the bounds of geological theory, trusting to the inevitable result that every new principle and fact discovered will soon find its economic application. Further, it is necessary that we should obtain as soon as possible a better knowledge of the mineral resources of the smaller and thinly inhabited colonies, protectorates, and spheres of influence. This is one of the things which would conduce to the more rapid and effective occupation of these areas.

With regard to areas not at present British colonies, it seems to me that no great harm would be done by obtaining, not in any obtrusive way, some general knowledge of the mineral resources of likely areas. This at least seems to be what other nations find it worth their while to do, and then, when the opportunity of selection arises, they are able to choose such regions as will most rapidly fill up and soonest yield a return for the private or public capital invested in them.

To sum up, I consider that the time has come when geologists should make a firm and consistent stand for the teaching of their science in schools, technical colleges, and universities. Such an extension of teaching will of course need the expenditure of time and money; but England is at last beginning to wake up to the belief, now an axiom in Germany and America, that one of the best investments of money that can be made by the pious benefactor or by the State is that laid up at compound interest, "where neither rust nor moth doth corrupt," in the brains of its young men.

This knowledge has been an asset of monetary value to hosts of individuals who have made their great wealth by the utilisation of our mineral resources, and to our country, which owes its high position among the nations to the power and importance given to it by its coal and iron. It is surely good advice to individuals and to the State to ask them to reinvest some of their savings in the business which has already given such excellent returns, so that they and we may not be losers through our lack of knowledge of those sources of energy which have made us what we are, and are capable of keeping for many years the position they have won for us.

And in our present revival of education it would be well that its rightful position should be given to a science which is useful in training and exercising the faculty of observation and the power of reasoning, which conduces to the open-air life and to the appreciation of the beautiful in nature, which places its services at the disposal of the allied sciences of topography and geography, which is the handmaid of many of the useful arts, and which brings about a better knowledge and appreciation of the life and growth of that planet which we inhabit for a while, and wish to hand on to our descendants as little impaired in vitality and energy as is consistent with the economic use of our own life-interest in it.



Memorial Tablet erected to

PROFESSOR HENRY ALLEYNE NICHOLSON,
M.D., D.Sc., F.R.S., F.G.S., &c., &c.,

In the University of Aberdeen: 1st August, 1903.

II.—Memorial to Henry Alleyne Nicholson, M.D., D.Sc., F.R.S.

(PLATE XXI.)

THE recently erected Memorial to the late Professor Henry Alleyne Nicholson, F.R.S., of Aberdeen, raised by subscription among his friends, deserves a record in the pages of this journal, to which he was for many years a frequent contributor (see Obituary of Nicholson, Geol. Mag., 1899, pp. 138–144, with a portrait, Plate IV).

Professor Charles Lapworth, LL.D., F.R.S., of the University of Birmingham; Mr. John E. Marr, M.A., F.R.S., St. John's College, Cambridge; Dr. Henry Woodward, F.R.S., late of the British Museum (Nat. Hist.); and Professor J. Arthur Thomson, M.A., who succeeded Nicholson as Regius Professor of Natural History in the University of Aberdeen, with very many others, decided to commemorate Nicholson's lifework by some simple yet permanent record; and after consultation with the University authorities it was decided that the memorial should take the form of a Tablet similar to that erected in Aberdeen to the memory of Macgillivray.

The preparation of a design was entrusted to Miss Alice B. Woodward, and the execution to the well-known artists in metal, Messrs. Omar Ramsden & Alwyn C. E. Carr, of Albert Studios, Albert Bridge Road, London, S.W.

The Nicholson Memorial Tablet (which measures 3 feet 8 inches by 2 feet 11 inches) is executed in hand-beaten and repoussé brass, mounted upon a stout framing of oak, and is a good example of the effort now being made to improve the artistic quality of such work, and render it more worthy of its object than the ordinary hurried modern machine-produced metal-work.

The principal motif of the design is a boldly conceived and modelled portrait medallion of Nicholson in 'John Knox' cap and gown, with an inscription setting forth his name and degrees, worked into the design after the manner of the delightful medals produced during the time of the Early Italian Renaissance, a treatment of the portrait-head which has never been surpassed. Beneath this is a square mass of lettering giving an epitome in ten lines of his career, with dates. The following is the full inscription:—

> "**HENRY ALLEYNE NICHOLSON, M.D., D.Sc., F.R.S.**
>
> BORN AT PENRITH SEPT. 1844.
> DIED AT ABERDEEN JAN. 1899.
> PROFESSOR OF NATURAL HISTORY:
> TORONTO, 1871. DURHAM, 1874.
> ST. ANDREWS, 1875. ABERDEEN, 1882–99.
> SWINEY LECTURER 1877–96.
> A SKILLED GEOLOGIST:
> AN UNTIRING INVESTIGATOR:
> EMINENT AS A TEACHER,
> BELOVED AS A FRIEND."

At either side, surmounted by two small Brachiopods of the genus *Orthis*, is a harmonious and elegant band of ornaments. composed of various natural forms of Graptolites gracefully and artistically interwoven, showing how a difficult problem in symbolical ornamentation can be overcome if properly approached with the necessary skill and power of design.

Above the head is a panel representing in low relief the wide expanse of the Cumberland mountains about Penrith, Nicholson's birthplace, and among which for so many years he laboured geologically, with the appropriate inscription "Levavi oculos meos in montes."[1]

Beneath the square inscription is a rich band of ornament, formed by the calices of the beautiful Silurian coral *Omphyma subturbinata*, and the inscription—

"He did a day's work and a man's work."[2]

At the lower corners are placed two Trilobites (*Phacops caudatus* and *Calymene Blumenbachii*) artistically worked out from specimens in repoussé brass, which form most valuable decorative bosses.

The particular idea which the artist had in view, and has successfully realised in the tablet, was to make it expressive of Nicholson's lifework and interests.

The work has been executed with great care and attention to detail, and shows the impression of the tool which is the natural result of hand-labour, and is free from the pockmarked appearance of many modern works in metal in which the hammer marks are applied, after the work is finished, by other than the legitimate hand-processes which, being an affectation, are as far from having any artistic merit as the highly polished machine-made product. The colour of the work is a natural oxidized brass, which harmonizes in a very restful manner with the oak slab upon which it is mounted, and being filled with lead at the back is as permanent as cast bronze, but still retains the lightness of hand-beaten work.

Professor J. Arthur Thomson, who acted with Mr. J. E. Marr in arranging for the Nicholson Memorial, has been untiring in his exertions to see this work carried out satisfactorily, and has rendered most valuable assistance to the artists throughout.

It is proposed that the Memorial Tablet, at present temporarily placed in the Natural History Museum in Marischal College, should find a permanent and prominent position in the new Geological Museum which is included in the extension of the University buildings now in progress.

The Memorial Tablet was handed over to the custody of the University of Aberdeen on Graduation Day, July 24th; it was received by the Very Rev. Principal Marshall Lang, D.D., and some of Nicholson's old colleagues paid eloquent tributes to his memory. H. W.

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[1] "I will lift up mine eyes unto the hills" (Ps. cxxi, 1).

[2] Suggested by Professor Lapworth.

III.—Fossiliferous Oldhaven Beds at Ipswich.

By Henry Bassett, Jun., B.Sc.

In the "Geology of the Country around Ipswich, Hadleigh, and Felixstowe"[1] Mr. Whitaker drew attention to the probable existence of Oldhaven Beds at Ipswich. On p. 11 he gives particulars of a section in Stoke brickyard. Below the London Clay at this spot occurred fine buff sand separated from the Clay by a thin pebble-bed containing fragments of shells. The buff sand was doubtfully referred to the Oldhaven Beds, while it was thought that the pebble-bed should also be included with these rather than regarded as a basement-bed of the London Clay. Below this doubtful Oldhaven sand occurred sands and mottled clays of the Reading Series. It was shown in the memoir that this pebble-bed occurred over a great part of this district with an outcrop along the valleys of the Gipping and the Brett. As a rule it rests on sands referred to the Reading Series, and is classed by Mr. Whitaker sometimes as basement-bed of the London Clay and occasionally as Oldhaven Beds.

Recently in Ipswich I came across a very clear section of these beds in one of the brickfields, and as they here show a rather unusual facies it seems worth while to draw attention to the section, especially as the beds contain many fossils at one spot. The section occurs on the north side of Messrs. Bolton & Laughlin's brickfield between the Norwich and Henley Roads. The brickfield is situated almost due north of Brook's Hall, and about 100 yards south of the railway line, but apparently at the time of the Geological Survey there was no brickfield at this spot; the pebble-bed, however, was shown in another pit (which still exists) a little further westward, and was included in the basement-bed of the London Clay by Mr. Whitaker. About 20 feet of London Clay are shown in Messrs. Bolton & Laughlin's pit, where it is overlain by Middle Glacial sands and gravel, with Chalky Boulder-clay above this a little way off. The London Clay is everywhere underlain by false-bedded, pale yellow sand, upon which, in many parts of the brickfield, the lower part of the clay rests directly; as a rule, however, there is a thin pebble-bed between the clay and the sand. As has been already mentioned, this pebble-bed occurs in many places round Ipswich, and in composition is exactly like the similar beds found near London, that is to say, it is composed almost entirely of small well-rounded black flint pebbles in a sandy matrix—a subangular pebble being only occasionally found.[2] However, at the spot I have mentioned it is found that the pebble-bed, which is there about a foot thick, has entirely changed its character, being composed of pebbles of various rocks, very few of which are well rounded. A large number of the pebbles are composed of hard clay, while there are others of sandstone and slightly rolled flints. The typical black well-worn flints characteristic of this horizon of the Eocene beds here form only a small proportion of the total. Another striking feature about the bed is that it is crowded with shells. These shells are quite perfect, but very fragile, and it is almost impossible to get them out whole. Sharks' teeth are also fairly abundant. The following shells and teeth have been obtained, and most of them were very kindly identified for me by Mr. E. T. Newton, F.R.S. The shells were so fragmentary that it was practically impossible to assign more than a generic name; it was much easier, in fact, to name them before removing them from the pebble-bed.

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[1] Mem. Geol. Survey: Explanation of Quarter-Sheets 48 N.W. and N.E., 1885.

[2] On p. 24 of the memoir already referred to Mr. Whitaker mentions finding a subangular flint in this pebble bed in a brickfield near Whitton.

Astarte (*tenera*? and *rugata*?).
Cardium.
Corbula.
Cyrena.
Cytherea (*orbicularis*?).
Ostrea (only one rolled fragment found).
Pectunculus.

Aporrhais.
Natica.
Teeth of—
  Odontaspis elegans, Ag.
  Odontaspis (*cuspidata*?). Ag.
  Lamna Vincenti, Winkler.
Teleostean fish vertebra.

Shells belonging to the genera *Astarte* and *Corbula* were much the commonest. The clay pebbles occurring in this bed have, I think, undoubtedly been derived from local beds of the Reading Series, for the clay is in every way similar in appearance to that occurring in the Reading Beds above the Chalk in the well-known section at Bramford, about two miles off. The sandstone pebbles have also very probably been derived from other beds of the same series. As the pebble-bed is traced westwards from the part of the section at which the shells occur, it is found that first of all it loses its abnormal character and is composed almost entirely of small black flint pebbles. A little further on, however, when about 40 yards from the starting-point, it has become still more unusual in its character, being now represented by a bed about 6 feet thick, composed almost entirely of clay pebbles of various sizes, from 1 to 12 inches in diameter. The clay pebbles lie with the original bedding-planes of the Clay at all angles to the somewhat indistinct bedding of the pebble-bed, and, as before, they have doubtless been derived from local Reading Clay beds. A few Chalk fragments also occur, and also a considerable amount of race.

The clay pebble-bed in some directions insensibly shades into the underlying sands, upon which it rests in an exceedingly irregular manner, and into which in some places it suddenly scoops down for a foot or two. The bedding approximately follows this irregular base-line. The normal type of flint pebble-bed, however, although it varies somewhat in thickness (from 0 to 1 foot), only does so gradually, and does not exhibit the very uneven base of the clay pebble-bed.

In a few parts of the pit there is a thin bed (a few inches thick) of rolled black flint pebbles between the clay pebble-bed and the overlying London Clay. This was well seen at the part of the section where the shells occurred, but unfortunately this part of the pit is now being filled up. It seems as though the two types of pebble-bed shaded more or less into one another, and, although occasionally the two occur one above the other, this is not usual.

The following represents a section at a spot where both types occurred together :—

		Feet.
LONDON CLAY.	Brown and grey bedded clay (with pyrites and selenite) ...	14
BASEMENT-BED OF LONDON CLAY.	Brown bedded loam with two thin dark clay bands containing pyritised fragments of wood, etc.	3
OLDHAVEN BEDS.	Bed of well-rolled black flint pebbles	0½
	Clay pebble-bed	2
READING BEDS.	False-bedded, pale yellow sand, with occasional small pebbles of clay and race near the top ... ... (seen)	6

Another point of interest is that the shells only occur in those parts of the pebble-bed which contain a considerable amount of clay pebbles, only sharks' teeth occurring in the parts consisting entirely of flint pebbles. This, no doubt, is due to the clay having protected the shells to a certain extent from the solvent action of percolating water.

On glancing at the list of shells from this spot it will be seen that nearly all of them belong to marine genera. This, of course, might be considered a good reason for including these pebble-beds in the basement-bed of the London Clay rather than classing them as Oldhaven Beds. In spite of this, however, it seems to me that the beds under discussion have as much right to be considered as belonging to the Oldhaven Series as the beds in many other places whose right is hardly questioned. In many cases the Oldhaven Beds differ from the overlying London Clay and the Woolwich and Reading Beds below chiefly in their lithological characters, which indicate strong currents and disturbed conditions. The assemblage of marine and fresh-water shells is by no means always found. Take, for example, the case of the Oldhaven Beds at Sundridge Park or Elmstead Cutting, Kent. Fossils are exceedingly abundant there, the most common being species of the genera *Ostrea, Pectunculus,* and *Corbula*; fresh-water shells, however, form only a very small percentage of the total, and they, moreover, nearly always are very much worn and have the appearance of drifted shells, while the marine shells are not worn at all. The beds here also show well two other characteristics of the Oldhaven Beds, namely, the sudden way in which they thicken out and the erosion of the underlying Woolwich and Reading Beds. Thus, in a distance of about a quarter of a mile, the Oldhaven Beds at Sundridge Park tunnel thicken from about a couple of feet to nearly 40 feet, at the same time scooping down into the underlying beds, so that finally they rest on Thanet Sand.[1] Both these features are seen, though on a smaller scale, in the corresponding beds at Ipswich, the sudden variations in the thickness of the beds having already been mentioned, while the erosion of the Reading Beds can be inferred from the occurrence of the clay pebbles.

The occurrence of the bed of clay pebbles containing large

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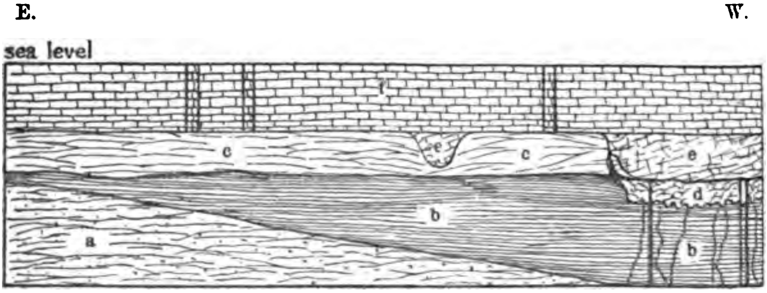
[1] See Whitaker, "Geology of London and Part of the Thames Valley," vol. i.

numbers of subangular flint and sandstone pebbles is very unusual and has not, I believe, been noticed before, and is no doubt merely an indication of strong local currents, together, perhaps, with a slight elevation bringing a neighbouring area of Reading Clay beds under the denuding action of the river which had originally deposited them. From the way in which this pebble-bed shades in some directions into the sands it would seem as though a certain thickness of the latter should be referred to the Oldhaven rather than to the Reading Beds, and, moreover, seeing that the pebbly beds insensibly disappear in certain directions, their absence in some places does not necessarily show that the Oldhaven Beds are there absent. Where the London Clay rests directly on the sands the Oldhaven Beds are very likely represented by the upper portions of these sands, the absence of pebble-beds merely indicating quieter water and absence of strong pebble-bearing currents at these spots when the beds were being deposited.

IV.—On a Section of the Thames Alluvium in Bermondsey.

By A. Santer Kennard and S. Hazzledine Warren, F.G.S.

During the early part of 1899 extensive excavations were made on the south side of Tooley Street, Bermondsey: just east of Shand Street, and on the site of Nos. 156–164, Tooley Street. The spot is about 250 yards from the present bank of the Thames. The whole area was excavated to a depth of about 10½ feet from the level of the pavement; below this, trenches and holes for the foundations were dug to a further depth of 6 to 8 feet. The section on the south side of the excavation is here given.



Section of the Alluvium of the River Thames in Tooley Street, Bermondsey.

a, Brownish sandy loam (Marsh Clay) with land shells; *b*, dark-coloured carbonaceous silt with fresh-water shells, Roman pottery, etc., and both ancient and modern piles driven into it under the old stream course; *c*, stratified made earth; *d*, river mud forming the bed of an old watercourse; *e*, brick rubbish; *f*, foundations and cellarage of the old houses.

Scale, horizontal and vertical, 18 feet to 1 inch.

The lowest bed seen, *a*, was a brownish sandy loam with a few pieces of burnt flint, very similar to those commonly seen in brickearths containing Neolithic flint implements, but nothing resembling a flint implement was found. It yielded a fair number of mollusca at one spot near the eastern end of the section, a small fragment of hand-made pottery, perhaps of Bronze age, a single tooth of a vole, and a few indeterminable fragments of bone. On the eastern side the top of this bed was about 11 feet from the street level, and it occurred almost immediately below the made earth *c*, but towards the west its upper part had been eroded away, and it was only touched at a few places at a depth of 16 to 18 feet.

Immediately succeeding this was a dark-coloured carbonaceous silt, *b*, containing abundant vegetable remains and mollusca. In places there were lenticular masses largely made up of shells. There were very few stones or bones, and no oysters were seen. Several fragments of Roman tile were found. Beetle remains also occurred, as well as numerous ostracods.

The succeeding bed, *c*, was made earth of the well-known London type, containing bones, shells of oyster, mussel, whelk, and *Helix aspersa*; fragments of pottery and objects of metal, perhaps belonging to the Stuart period, but certainly not older than Tudor.

The western end of the excavation was perhaps the most interesting. Here was the filled-up course of an old stream that ran across the area from south to north. The banks could not clearly be made out, but two rows of well-preserved modern piles 9 to 10 feet apart, with cross-beams and planks nailed on to them, probably marked its artificial banks at some not very distant period. The section of the filled-up bed was:—

3. Modern brick rubbish.
2. Partly stratified river mud, *d*, containing bricks, pieces of roofing slate, lumps of chalk, oyster and mussel shells, bones, and a few non-marine mollusca.
1. Carbonaceous silt, *b*, identical with that present elsewhere in the section.

The junction of the river mud with the bed below was much disturbed, probably by the grounding of boats. In the carbonaceous silt were a large number of ancient piles made of more or less crooked, small stems, or boughs of trees. They were in an advanced stage of decay; the wood being quite spongy and soft, in this respect contrasting markedly with the modern piles described above.

We would here take the opportunity of thanking Mr. Clement Reid, F.R.S., for kindly identifying the plant remains, Mr. C. O. Waterhouse for naming the insects, and Mr. B. B. Woodward for assistance with the mollusca.

LIST OF FOSSILS FROM THE MARSH CLAY (BED *a*).

VERTEBRATA.

Microtus glareolus (Shreb.), (Bank Vole).

MOLLUSCA.

Agriolimax agrestis (Linn.).
Vitrea cellaria (Müll.).
,, *crystallina* (Müll.).
Arion ater (Linn.).
,, *hortensis*, Fér.
Pyramidula rotundata (Müll.).
Hygromia hispida (Linn.).
Helicigona arbustorum (Linn.).
Helix aspersa, Linn.
,, *nemoralis*, Linn.
Cochlicopa lubrica (Müll.).
Pupa muscorum (Linn.).

Cæcilioides acicula (Müll.).
Succinea elegans, Risso.
Neritina fluviatilis (Linn.).
Bithynia tentaculata (Linn.).
Limnæa pereger (Müll.).
,, *palustris* (Müll.).
Planorbis Stroemii, West.
,, *contortus* (Linn.).
,, *vortex* (Linn.).
,, *carinatus*, Müll.
Pisidium amnicum (Müll.).

LIST OF FOSSILS FROM THE CARBONACEOUS SILT (BED *b*).

VERTEBRATA.

Homo sapiens.
Sheep or Goat.
Bos longifrons (Ox).
Anguilla anguilla (Eel).
Leuciscus rutilus (Roach).
Rana temporaria (Frog).

MOLLUSCA.

Agriolimax agrestis (Linn.).
Vitrea cellaria (Müll.).
,, *crystallina* (Müll.).
,, *nitida* (Müll.).
Arion ater (Linn.).
Pyramidula rupestris (Drap.).
,, *rotundata* (Müll.).
Hygromia hispida (Linn.).
Helicigona arbustorum (Linn.).
Helix aspersa, Linn.
,, *nemoralis*, Linn.
Carychium minimum, Müll.
Neritina fluviatilis (Linn.).
Bithynia tentaculata (Linn.).
,, *Leachii* (Shepp.).
Valvata piscinalis (Müll.).
,, *cristata*, Müll.
Succinea elegans, Risso.
Physa fontinalis (Linn.).
Limnæa pereger (Müll.).
,, *palustris* (Müll.).
,, *truncatula* (Müll.).
Planorbis corneus (Linn.).
,, *marginatus*, Drap.
,, *carinatus*, Müll.
,, *spirorbis*, Müll.
,, *vortex* (Linn.).
,, *contortus* (Linn.).
,, *albus*, Müll.
,, *Stroemii*, West.
,, *fontanus* (Light.).
Sphærium corneum (Linn.).
,, *lacustre* (Müll.).
Pisidium amnicum (Müll.).
,, *subtruncatum*, Malm.
,, *nitidum*, Jenyns.
,, *obtusale*, Pfr.
,, *milium*, Held.

Littorina littorea, Linn.
Cardium edule, Linn.
Macoma Balthica, Linn.
Mytilus edulis, Linn.

INSECTA.

Pupæ of Diptera.
Pterostichus (*madiolus* ?).
Hister cadaverinus.
Geotrupes spiniger.

PLANTÆ.

Ranunculus acris, L.
,, *repens*, L. (Buttercups).
,, *sardous*, Crantz
Silene Cucubalus, Wibel (Bladder Campion).
Stellaria graminea, L. (Lesser Stitchwort).
Linum usitatissimum (?), L. (Flax).
Vitis vinifera, L. (Grape).
Prunus spinosa, L. (Sloe).
,, *domestica*, L. (Damson).
Rubus fruticosus, L. (Blackberry).
Potentilla Tormentilla, Neck. (Tormentil).
Pyrus Malus, L. (Apple).
Apium nodiflorum, Reichb.
Fœniculum officinale, Adanson (Fennel).
Heracleum sphondylium, L. (Hogweed).
Caucalis nodosa, Scop.
Sambucus nigra, L. (Elder).
Chrysanthemum segetum, L. (Corn Marigold).
Cnicus lanceolatus, Hoffm. (Thistle).
Cnicus palustris, Hoffm. (Thistle).
Centaurea scabiosa (?), L. (Hard-heads).
Sonchus oleraceus, L. (Sow-thistle).
Solanum, sp. (Nightshade).
Prunella vulgaris, L. (Self-heal).
Galeopsis Tetrahit, L. (Hemp-nettle).
Atriplex patula, L. (Orache).
Polygonum aviculare, L. (Knot-grass).
,, *Hydropiper*, L. (Water-pepper).
,, *amphibium*, L.
Rumex conglomeratus, Murr. (Docks).
,, *obtusifolius*, L.
Urtica dioica, L. (Stinging-nettle).
Ficus carica, L. (Fig).
Alnus ? (Alder).
Quercus (Oak).
Alisma Plantago, L. (Water Plantain).
Potamogeton natans, L. (Pondweed).
Zannichellia palustris, L. (Horned Pondweed).

LIST OF FOSSILS FROM THE RIVER MUD (BED *d*).

VERTEBRATA.

Sheep or Goat.
Equus caballus, Linn. (Horse).
Bos longifrons, Owen (Ox).
Sus scrofa, Linn. (Pig).

MOLLUSCA.

Bithynia tentaculata (Linn.).
Valvata piscinalis (Müll.).
Limnæa pereger (Müll.).
,, *truncatula* (Müll.).
,, *stagnalis* (Linn.).
Planorbis Stroemii, West.
,, *contortus* (Linn.).
Planorbis vortex (Linn.).
Sphærium corneum (Linn.).

Ostrea edulis, Linn.
Mytilus edulis, Linn.
Cardium edule, Linn.

NOTES ON THE FOSSILS.

Bed *a* (pre-Roman). The slug remains were very abundant, especially the granules representing the internal shell of the Arionidæ. The examples of *Helix nemoralis* were large, several measuring 24 mm. in diameter. The Bank Vole was represented by a single typical tooth. The land mollusca were greatly in excess of the fresh-water forms, not only in the species, but still more so numerically. The whole assemblage is that of the fauna of a damp land surface, subject to periodical flooding, the aquatic forms being then washed on to it.

Bed *b* (Roman). In this layer the land shells were comparatively scarce, except in one or two places. The most noteworthy form is undoubtedly *Pyramidula rupestris*, which has hitherto been undetected in a fossil state. It is only represented by one example, but its distribution in these Islands is such that its occurrence in the Pleistocene is to be expected.

Another interesting form is *Sphærium lacustre*, which is an extremely rare form in a fossil state, being only known in these Islands from the Pleistocene of Barnwell and the Holocene (Roman) of London Wall. The facies of the mollusca is that of a typical Thames Holocene bed. There is no trace of any tidal influence, the marine shells without doubt owing their presence to the hand of man.

NOTE ON THE PLANTÆ FROM BED *b*. By MR. CLEMENT REID, F.R.S.

The list suggests a moist ditch into which a certain amount of house-refuse had been thrown. Most of the species are common plants of wet meadows, but amongst them are remains of several cultivated plants. The vine, damson, apple, and fig occur, and the flax and fennel also were probably cultivated. The corn marigold and hemp-nettle suggest weeds of cultivation, though in this small collection they are not associated with remains of cereals.

There is a close resemblance between this list and that from Roman Silchester, where also seeds of the vine and fig occur. A larger collection from Tooley Street will be of great interest, for the plants should throw much light on the condition of Roman London. Two of the species have not been before obtained from deposits of so ancient a date; they are the bladder campion and the fennel.

CONCLUSIONS.

The sandy loam *a* is, in our opinion, the equivalent of the marsh clay present in so many of the sections of the Holocene alluvium of the Thames, and without doubt is of the same origin—a land surface liable to flooding, each flood adding to the thickness of the deposit. The old stream was a tributary of the Thames, and it probably flowed in the same course when bed *a* was deposited. The age of this bed is certainly pre-Roman. The gradual sinking of the lower Thames Valley, which has been in operation since the close of the Pleistocene period, at length enabled the influence of the main stream to be felt, and the carbonaceous silt was deposited. From the presence of Roman pottery in this latter bed it is evident that this did not take place in pre-Roman times, and the deposition of the bed was no doubt carried on for several centuries. Lastly, we have the modern reclamation, the piling of the stream, and finally the filling up of the stream course and the erection of buildings.

V.—ON THE BASE OF THE KEUPER IN SOUTH DEVON.[1]

By ALEX SOMERVAIL.

WHILE appreciating and agreeing with the valuable work done by Dr. Irving and Professor Hull, dealing with the New Red rocks of South Devon, as set forth in their papers on this subject in the Quart. Journ. Geol. Soc.,[2] there is only one point in which I differ from these authors; it is in relation to the rocks forming the base of the Keuper in this area.

In the last of these papers both authors agree to regard certain breccias occurring at the mouth of the river Otter, and again at the mouth of the river Sid on its eastern side, as the basement beds of the Keuper.

The basement breccias of the river Sid section, as explained by them, are the Otterton breccias again brought up, and repeated by the fault which occurs at the Chit rock, where the sandstones on the east side of the fault are brought up against the Keuper marls on its west side.

The breccias near the mouth of the Otter have been described by Dr. Irving as calcareous or dolomitic breccias, or conglomerates, which I think quite a correct description of these beds. This description, however, *certainly does not* apply to the alleged breccias on the left bank of the Sid, to which I shall presently refer.

The Otterton breccias or conglomerates have been traced inland by Dr. Irving to various localities, all of which I have visited and have found correctly described. The breccias in the inland localities are, however, all along the strike of the Otterton Beds, and not in any case, along the strike of the alleged breccias said to occur in the Sidmouth section.

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[1] Read before the British Association, Southport, Section C (Geology), Sept. 1903.

[2] See Quart. Journ. Geol. Soc., vols. xliv, xlviii, and xlix.

The principal object of my short paper is to show that the Otterton breccias are *not again* brought up on the east side of the Sid, or even on its west side at the fault at the Chit rock; but that they occupy a much lower horizon, and are separated from the beds on the east side of the Sid by a great thickness of sandstones seen between Otterton Point, Ladrum Bay, and the base of High Peak Hill. Still higher beds of these sandstones are even continued further to the west of the latter locality, until they are overlain by the Keuper marls, just before reaching the fault.

My object will be best obtained by a brief description of the coast section between the Budleigh Salterton Pebble-bed and the cliff on the east side of the river Sid.

Immediately overlying the pebble-bed is a considerable thickness of soft red sandstones terminating on the west side of Budleigh Salterton.

Near the Lifeboat Station these sandstones are overlain by another series of sandstones containing breccias, and concretionary-like masses of limestone which are continued to the east side of the river Otter, where the breccias occur which Dr. Irving regards as his Keuper basement series.

From Otterton Point eastwards these breccias are overlain by a series of red sandstones, which can be studied as a slowly ascending series to Ladrum Bay, the base of High Peak Hill, and further along the coast to within a little distance of the fault at the Chit rock.

Between the base of High Peak Hill and some little distance west of the fault the red sandstones are strongly marked by current bedding. The higher portions of these same sandstones are also characterized by a nobbly or concretionary-like structure; but the term breccia, if applied to them, would, I think, be a misnomer. Above these concretionary-like beds are other sandstones of only a few feet in thickness, of a greyish-white colour, which at once pass upwards into the true Keuper marls.

It is highly important to note that it is the effect of the fault at the Chit rock to bring up here, *not the Otterton breccias*, but the higher portion of these current-bedded red sandstones; so that the fault is one of no great magnitude. The entire displacement, I think, is not more than 50 feet, if as much; while the thickness of the sandstones intervening between the Otterton breccias and the line of fault, I would roughly estimate at 150 feet or more.

At the section under dispute on the east side of the Sid, beds still higher in the series occur. These beds consist of the uppermost portion of the current-bedded and concretionary-like sandstones, surmounted by the pale-grey sandstones of only a few feet in thickness which are immediately overlain by the Keuper marls.

The whole thickness of the sandstones with the alleged included breccia and underlying sandstone below the marls in the section figured by Professor Hull[1] would not amount to more than 20 feet in all; while the Otterton breccias must be separated from the lowest bed of the section here exposed by fully 150 feet.

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[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 66.

That the Otterton breccias should form a basement for the Keuper in South Devon, I have no great objections to offer. These breccias, however, as the authors are well aware, are only a small portion of still lower beds of the same nature seen on the west side of that river, and extending along the Promenade until they are underlain by the red sandstones which in their turn overlie the Budleigh Salterton Pebble-bed.

These beds are of considerable thickness, 100 feet or more, and possess many distinguishing features. They are essentially different from any other beds in the Trias. Their dolomitic breccias or conglomerates, and the accompanying masses of concretionary limestone, would almost mark them off as a good representative of the missing Muschelkalk, if this formation has an equivalent in England.

It is the immediately overlying mottled or current-bedded sandstones seen between Otterton Point and the east side of the Sid, that I would regard as the base of the Keuper, in which have been found the remains of the *Hyperodapedon*. This is a point, however, that I would not by any means urge if it be considered that the missing Muschelkalk has no true equivalent or representative in our own country.

The chief object of my paper will have been attained if it is deemed that I have shown sufficient evidence for the conclusions that the Sidmouth section has been misread by Professor Hull and Dr. Irving, and that the Otterton breccias are on a far lower horizon than the alleged breccias (?) in the Sidmouth section.

NOTICES OF MEMOIRS, ETC.

British Association for the Advancement of Science. Seventy-third Annual Meeting, held at Southport, September 9–16, 1903.

List of Papers read in Section C, Geology.

Professor W. W. Watts, M.A., M.Sc., F.G.S., President.

The President's Address.—Geology in Education and Practical Life.

J. Lomas.—On the Geology of the Country around Southport.

Harold Brodrick.—On the Geology of Martin Mere.

A. Smith Woodward, LL.D., F.R.S.—Report of the Committee on the Registration of Type-Specimens of Fossils.

Professor H. A. Miers, F.R.S.—Report of the Committee on the Structure of Crystals.

André Delebecque.—On the Lakes of the Upper Engadine.

H. B. Muff and W. B. Wright.—On a Pre-Glacial or Early Glacial Raised Beach in County Cork.

G. W. Lamplugh.—On Land Shells in the Infra-Glacial Chalk Wash at Sewerby, Yorkshire.

Report of the Committee on the Estuarine Deposits at Kirmington, Lincolnshire.

Report of the Committee on Erratic Blocks.

Report of the Committee to Explore Irish Caves.

Report of the Committee on Underground Waters of North-West Yorkshire.

Report of the Committee on Geological Photographs.

Dr. Wheelton Hind.—On the Practical Value of certain Species of Molluscs in the Coal-measures.

Report of the Committee on Life Zones in the Carboniferous Rocks.

W. S. Boulton.—On the Igneous Rocks of Weston-super-Mare.

J. J. H. Teall, F.R.S.—On Dedolomitization.

A. C. Seward, F.R.S.—Notes on the Fossil Flora of South Africa.

A. Smith Woodward, LL.D., F.R.S.—On a Carboniferous Acanthodian Fish—*Gyracanthides.*

A. Smith Woodward, LL.D., F.R.S.—On the supposed evidence of an Anomodont Reptile from Brazil.

J. Lomas.—On Polyzoa as a Rock-cementing Organism.

T. H. Cope and J. Lomas.—On the Igneous Rocks of the Berwyns.

W. G. Fearnsides.—On the Lower Ordovician Rocks in the Neighbourhood of Snowdon and Llanberis.

E. A. Newell Arber.—On the Fossil Flora of the Ardwick Series of Manchester.

J. Lomas.—Report of the Committee on the Fauna and Flora of the Trias.

A. Somervail.—On the Base of the Keuper in South Devon. (p. 460.)

G. W. Lamplugh.—On the Disturbance of Junction Beds from Differential Shrinkage during Consolidation.

J. G. Goodchild.—On some Contorted Strata occurring on the Coast of Northumberland.

J. G. Goodchild.—Some facts bearing on the Origin of Eruptive Rocks.

J. G. Goodchild.—On a possible Cause of the Lethal Effect of the Dust ejected during the Recent Volcanic Eruptions in the West Indies.

J. G. Goodchild.—Notes on the Metalliferous Deposits of the South of Scotland.

J. Jowett.—Glacier Lakes and Overflow Valleys in the Neighbourhood of Rimington.

William MacKie.—On the Origin of Continents and Ocean Basins.

W. Whitaker, F.R.S.—Report of the Committee on Changes along the Coastline of the British Isles.

H. W. Monckton.—Notes on the Sarsen Stones of Stonehenge and on those found in the Bagshot District.

Llewellyn Treacher.—On the occurrence of Stone Implements in the Thames Valley, between Reading and Maidenhead.

J. Lomas.—On the Origin of certain Quartz Dykes at Foxdale, Isle of Man.

H. J. Seymour.—Supplementary List of Minerals known to occur in Ireland.

F. P. Mennell.—On the Average Composition of the Igneous Rocks.

Papers bearing on Geology read in other Sections:—

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

J. Milne, F.R.S.—Report of the Seismological Committee.

D. Burns.—Phenomena accompanying the Volcanic Eruptions in the West Indies.

SECTION E.—GEOGRAPHY.

Captain E. W. CREAK, C.B., R.N., F.R.S., President.

President's Address (refers to Terrestrial Magnetism and Geology).

Dr. Tempest Anderson, M.D., B.Sc.—The Recent West Indian Eruptions.

C. E. Moss.—Peat Moors of the Southern Pennines: their Age and Origin.

SECTION G.—ENGINEERING.

CHARLES HAWKSLEY, M. Inst. C. E., President.

President's Address (refers to Water Supply).

J. Campbell Brown.—On the Nature and Quality of some Potable Waters in South-West Lancashire.

J. Parry.—Water Supply and South-West Lancashire.

R. Pearson.—History of the Discovery of Natural Gas in Sussex.

SECTION H.—ANTHROPOLOGY.

J. G. Garson, M.D., and W. J. Lewis Abbott.—Some Recent Excavations at Hastings, and the Human Remains found.

Mrs. Stopes.—Palæolithic Implements from the Shelly Gravel Pit at Swanscombe, Kent.

Mrs. Stopes.—Saw-edges in Flints from Swanscombe, Kent.

Nelson Annandale, B.A.—The Survival of Primitive Implements in the Faroes and Iceland.

SECTION K.—BOTANY.

A. C. SEWARD, F.R.S., F.G.S., President.

President's Address.—Floras of the Past: their Composition and Distribution.

Dr. D. H. Scott, F.R.S., and Professor F. W. Oliver.—The Seed of *Lyginodendron.*

W. Wilson.—The Plants on the Serpentine Rocks in the North-East of Scotland considered with reference to the Soil Ingredients.

REVIEWS.

I.—Catalogue of the Madreporarian Corals in the British Museum (Natural History). Vol. IV: The Family Poritidæ. 1. The genus *Goniopora*. By HENRY M. BERNARD, M.A. 4to; pp. viii and 206, with 14 plates. London: printed by order of the Trustees, 1903. Dulau & Co., Soho Square.

THIS is the fourth volume on Corals issued by the Trustees of the British Museum (Natural History). Vol. i, by the late George Brook, on the genus *Madrepora*, appeared in 1893 (pp. xii and 212, with 35 quarto collotype plates of the genus *Madrepora*); there were at that time in the collection 1104 specimens, described by Mr. Brook under 180 specific names, the total number of species of the genus amounting to 221. Vol. ii, embracing the genera *Turbinaria* and *Astræopora*, was, through the lamented death of that accomplished zoologist Mr. George Brook, undertaken by another excellent biologist, Mr. Henry M. Bernard, M.A., F.L.S., F.Z.S., and appeared in 1896 (pp. iv and 106, with 33 plates). Vol. iii, containing the corals of the genera *Montipora* and *Anacropora*, prepared by the same author, was issued in 1897 (pp. viii and 192, with 34 plates 4to). In 1897 the late Sir William Flower, then Director, writing in the Preface, said: "The three volumes now finished form together a very complete monograph of the Madreporidæ, which is one of the chief reef-building families of Stony Corals. . . . In 1878, when Brüggemann prepared his manuscript catalogue, there were only 41 specimens of Montipores, divisible into 16 species. There are now more than 400 specimens, classed under 116 species, about 80 of which are new."

In the preface to vol. ii Mr. Bernard refers (pp. 19–21) to the difficulties which beset the systematic naturalist in attempting to establish a standard upon which to divide Corals into groups—say according to their methods of growth. These methods of growth, which at first seem so convenient, are found to pass into one another, so that it is most perplexing to decide whether a specimen exhibits one or the other type of growth.

Again, the number of transitional forms observable in a long series of specimens, which, from their calices, are clearly related, renders it difficult to decide as to which group they properly belong. Still more serious is the fact that in Torres Straits we find Turbinarians widely differing in the character of their calices, yet revealing exactly the same methods of growth, which shows that in that case at least the form of the corallum is due to the environment. Often, too, special local forms of growth are confined entirely to limited areas.

A year later, writing at p. 17 in vol. iii, Mr. Bernard says: "While claiming that the chief divisions of the genus are natural divisions, I can only repeat what was said in the preface to vol. ii as to the real value of the specific divisions. The types represent merely the more marked variations presented by the specimens in the collection, and are therefore for the most part purely artificial groupings. Only in those cases in which the individual specimens are known to have been collected from the same locality, and might almost be fragments of one and the same colony, does the name imply the close blood-relationship which the word species should be taken to connote. In all other cases the types are, strictly speaking, only morphological groups united because of certain peculiarities of form or structure which they have in common. Their ultimate systematic value is thus problematical. How much this is the case, indeed, may be gathered from the fact that the differences presented by specimens which are undoubtedly specifically identical may be far more striking than those that separate many of the types."

"The influence on the mind of the puzzled worker by such a group of many individuals, showing great variations, yet undoubtedly specifically identical, leads him, as a rule, temporarily to a wholesale lumping of other specimens, until his courage fails him, when the more striking individual variations are once more separately described as new types."

The above extracts will serve to convey the feelings of the author in regard to the use and limitation of the term 'species.' Indeed, so far back as 1896 he wrote: "It seems to me certain that we are rapidly nearing the time when our ever-increasing collections, revealing as they do the infinite grades of variation presented by living organisms—especially by stock or colony-forming animals, such as corals, in which the varying factors are doubled,—will compel us to break loose from the restraint of the Linnean 'species.'"

We come now to the latest issue of Mr. Bernard's work on corals (vol. iv, August, 1903), issued under the favourable auspices of Professor E. Ray Lankester's administration as Director and Keeper of Zoology. By the Director's advice, the author has made a special study of the rich collection of fossil corals contained in the Geological Department, which has revealed the fact that an important Tertiary coral, *Litharæa*, is generically identical with *Goniopora*, and this genus can now be traced back to early Cretaceous times, and had its period of maximum development in the early Tertiary beds of South Europe. The fossils, moreover, throw much light upon the morphology of the genus.

"The variability of the corals" (writes Professor Lankester) "has, in previous volumes, been a good deal obscured by the establishment of a number of so-called species; the author has thought it right to cease establishing genetic groups without the necessary data for so doing. He regards his task as that of presenting the facts and what may legitimately be deduced from them in the way that will be most useful to future workers and to the officials of other museums. Experience alone can show whether the method he has adopted in order to attain this end, however faultless its logic may be, can be employed with advantage in dealing with any other group besides the corals, or even whether it is the best way of presenting the corals, having regard solely to the facts. The attempt is, however, a sign of the times, for it is clear that, whether the older school of systematists like it or not, the question of method is an increasingly serious one, and Mr. Bernard's attempt should stimulate inquiry outside the beaten paths." (Introduction, p. i.)

The first thing that will strike the reader is the change in the formula, the author having completely abandoned the old methods of naming in favour of geographical symbols.

"It must, of course" (writes Mr. Bernard, p. 190), "be at once admitted that names like those usually employed to indicate species might have been used instead of geographical symbols. But the objections to names seem to be many and serious.

"A 'specific name,' by long usage and almost universal agreement, implies a true genetic group, and my experience has been that no explanation as to the meaning assigned to the use of the name can change this. When we are not dealing with species, but with forms, from the ultimate grouping of which species may perhaps be discovered, the work is confusing if the method of designation for the forms is that used for species. Some special method is needed for this preliminary analytical stage of work. Only when the natural groups have been discovered should names be used.

"The use of some special symbol for this preliminary study becomes obvious if we picture to ourselves what must happen as soon as true genetic groups or species can be compounded from series of known forms. One of the names will be retained as the name of the species, others as the names of varieties, while the rest will have to be discarded as mere synonyms. Working symbols have this advantage over ordinary specific names, that they can be legitimately discarded if we so desire. But it seems to me that, while we would certainly desire to discard a wearisome and perfectly unintelligible list of synonymous *names*, there would be no desire to discard synonymies composed of geographical symbols, for they would give at a glance the geographical distributions of the species and of its several varieties.

"The attempt here made to record forms is being made in other groups besides corals, but so far only in such groups as have already been divided into species. The process involves the addition to the accepted specific name of one or more qualifying names, one of which invariably indicates the locality. In this way the old binominal designation of Linnæus is forming the basis for a multinominal system of recording the various forms which we now find embraced by the species. This system cannot be adopted in the corals, for the simple reasons that only a very small proportion of the corals have yet received any names at all, and only a few of those which have been named can now be identified. The process is, therefore, not one of designating the forms which make up established species, but of recording forms which may some day be grouped into species. We who are working with corals, then, are in a position favourable to the adoption of a new and more straightforward method of dealing with the species problem. In reality we are still in the throes of sorting out genera, and all the most solid work of the past is chiefly valuable in this respect. Even this stage is far from complete. The task, therefore, is complicated, and the new method should be technically simple, practical, and efficient.

"The question thus arises, whether names or symbols best fulfil these conditions. Names, when there are only a few of them, may be easier to remember, but long lists are a dead weight upon the work. While there may ultimately prove to be but few *groups* or *species* requiring names, the number of *forms* to be designated is bound to be very large. For example, the analytical tables which now give at a glance the geographical distribution of the different structural divisions would have been far less useful if meaningless names had been given to the forms. It seems to me that we have no other alternative than that between 'trivial' names and symbols. It is not possible to invent a long list of short names, each one of which shall convey useful information, except on some fixed plan, and that, sooner or later, means the construction of symbols or of symbolic names." (p. 191.)

Notwithstanding this bold and determined attempt to reform zoological nomenclature, and to rid us of the long lists of synonyms which fill so many pages of every systematic work, the author has to admit that he has been warned again and again that there are rigid formalists who firmly believe they would be doing zoology a service by *naming*, that is, "*making species*" of, all the forms here recorded by geographical symbols. Mr. Bernard, from recent experience, finds he is compelled to respect this warning and to give a list of Latin equivalents for his geographical symbols which may stand instead of *specific names*, which the *rigid formalist* may catalogue and accept as such. One hundred and forty-four of these provisional names are listed, each preceded by the author's symbol, which he is warned will not be accepted in lieu of a name, so they read thus:—

GONIOPORA: (symbol) *G. New Guinea* 1 (which stands for, or is) = *Goniopora Nova-guineensis prima* [and in those cases in which the forms have been assumed by previous writers to represent separate and distinct *species*, the name of such species is given in brackets; thus to the above name we must add (*G. pedunculata*, Quoy & Gaimard)]; *G. New Guinea* 2 = *G. Nova-guineensis secunda*; *G. New Ireland* 1 = *G. Nova-hibernica prima*; *G. Solomon Islands* 1 = *G. Salomonis prima*; and so on.

Two objections present themselves to Mr. Bernard's admirable proposals—yea, three might be urged—(1) The symbol alone is insufficient. (2) The name in full in addition or in place of the symbol is *too long*.[1] (3) Is it not unfair to annex all the geographical names for one group? Furthermore, it involves the introduction of the *trinomial system* into zoology, which is certainly not a thing to be greatly desired. The symbols alone, we fear, will not meet with cordial acceptation in any case.

The main difficulty which will be felt by systematic zoologists in adopting Mr. Bernard's method of nomenclature in corals is that it is unlike that in use for similar natural divisions, so that this class of organisms must stand aloof from, and cannot conveniently be brought into line with pre-existing arrangements of other orders and families.

Whatever attitude we may adopt with regard to Mr. Bernard's system of nomenclature we must all be most grateful to him for one thing, namely, that he has taken in hand the long neglected fossil Zoantharia, and is tracing out their existing relationships with the same careful and philosophical attention which he has bestowed upon the living corals.

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[1] Especially when we have so often to use some other name as well to qualify it, as pointed out above (viz. *G. pedunculata*, Q. & G.). There are 51 such additional recognised names which must be used and cannot be set aside.

In the present volume the author writes (p. 28): "The Eupsammiidæ and *Goniopora* appear to have arisen in Mesozoic times, the earliest known Goniopore being from the Lower Cretaceous formation of the Crimea, since which time the perforate corals have flourished, belonging for the most part to the Tertiary period." (Earlier corals, claimed to belong to the Poritidæ, including *Calostylis*, of Lindström from the Silurian, have so far not borne the test of examination.) Mr. Bernard then proceeds to deduce the origin of *Goniopora* and *Porites* (forming the Poritidæ) and the Madreporidæ from the Eupsammiidæ.

These primitive relationships are illustrated in the following scheme. A primitive porous coral, that is, a parent form in which the epithecal cup, or the prototheca, is flattened out, and the secondary theca is built of septa joined by synapticulæ:—

Simple and simply branching forms.	Luxuriantly branching forms, owing to early budding and consequent dwarfing of the polyps, but with rapid growth in height of theca.	Astræiform colonies, due to early budding while the skeleton is incomplete, basal and disk-shaped.
The Eupsammiidæ.	**The Madreporidæ.**	**The Poritidæ.**
[? Including TURBINARIA.]	[? Excluding TURBINARIA.]	GONIOPORA. By suppression of tertiary septa. PORITES.

The author inserts under "Geographical arrangement of forms" all the fossil genera and species where they appropriately belong.

Thus at p. 92. Group V, **India and Persia**, *containing descriptions or records of fossil Goniporæ from Sind* (1–7), *Indus River* (1), *Persia* (1–4).

62. *Goniopora*, **Sind** (7) 1; and then in what we should consider the synonymy we find:—

Litharæa epithecata, Duncan: Sind Fossil Corals, Mem. Geol. Surv. India, 1880, p. 23, pl. ii, figs. 1–9; Geol. Dept. R. 13, presented Geol. Surv. India.

A full description follows, and of 11 other species (pp. 92–99). Under Red Sea and Egypt, 3 fossil forms are described (pp. 99–107). Under Italy, fossil *Goniporæ* are described from Vicenza (1–13), Verona (1–2), Alexandria (1–3), Turin (1–3), Genoa (1–5), (pp. 107–122). Under Austria-Hungary we find Miocene corals from Vienna, Cretaceous from Bohemia, etc. Under France we have many forms from the Miocene of Dax, Gironde, Paris Basin, Coutances, etc. (pp. 128–146). Under England we find fossil

Goniopora from Bracklesham Bay and Brockenhurst (pp. 147–153). Russia furnishes a Lower Cretaceous form from the Crimea (pp. 153–154). There is also a form from the Eocene of Somaliland described by Gregory. In the analytical tables of results (pp. 162–168) the fossil forms have their appropriate places, as e.g. No. 46, Java Sea 2 and 3, Valley of the Tjilanang, Ronga, Upper Miocene, and 4, near Liotjitjangkang, also U. Miocene. Then Eocene, India; Miocene, Persia; Eocene, Egypt; and so on, down to Upper Cretaceous, Bohemia, and Lower Cretaceous, Crimea.

The last table gives us a summary of the whole of the known forms of *Goniopora*, with their geographical and geological distribution, showing Cretaceous 5, Eocene 35, Oligocene 20, Miocene 19, Pliocene 1, Pleistocene 1, Recent 70, giving a grand total of 151 forms, or *possible* species.

There is an interesting survey of growth-forms and their distribution (pp. 169–186), and the summary of results (pp. 187–189). "The only specimens" (of corals), says Mr. Bernard, "showing unmistakeable genetic affinities are those which have been gathered from the same spot and are obviously daughter-colonies of one and the same parent."

"The largest area over which such a genetic group is as yet known to spread is that of the Maldive Islands. One simple form of Gonioporan colony, with calicles which are those characteristic of its type of growth, has been discovered by Mr. Gardiner occurring at considerable depths round at least four of these islands," the evidence showing that they are all alike developed on a soft muddy bottom. "This determined *the growth-form*, and this is largely responsible for the type of the calices" (p. 188). Mr. Bernard thinks that "The Stony Corals are still too elementary in their organisation to be able to acquire any but transient stability, if such an expression can be admitted; they also respond very quickly to their environment."

"The chief results, then," says Mr. Bernard, "are practically all that could be expected from the relatively small amount of the material. They are almost exclusively morphological, phylogenetic, and biological. The systematic arrangement of the forms in the order of their evolution cannot yet be attempted."

We desire to record our admiration for the plates, especially those of the present volume, in particular plates i to x^b, giving enlarged views of portions of growth-forms from various examples (numbers and localities given in each case). These, which are enlarged five times natural size by photography, far exceed in beauty and accuracy of detail those of the previous volumes.

We heartily commend Mr. Bernard's work to the attentive consideration of all zoologists, and more especially of those who are interested in recent and fossil corals, although, if the author carries his point, all the *species* of corals must, in the near future, remain nameless, like the 'Masque de Fer,' or be represented only by a locality and a number!

I.—MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES.

l.—The Geology of the South Wales Coalfield. Part IV: The Country around Pontypridd and Maes-Têg, being an account of the region comprised in Sheet 248 of the Map. By AUBREY STRAHAN, M.A., F.G.S., R. H. TIDDEMAN, M.A., F.G.S., and WALCOT GIBSON, B.Sc., F.G.S. 8vo; pp. vi and 134, with plate of sections and 6 text illustrations. (Issued July, 1903; preface dated 28th February, 1903. Price 1*s.* 6*d.*) Illustrating Sheet 248 of the Geological Map of England and Wales (scale 1 inch to 1 mile), colour printed. (The map is sold separately, price 1*s.* 6*d.*)

.—The Geology of the Cheadle Coalfield. By GEORGE BARROW, F.G.S. 8vo; pp. iv and 62, with 2 illustrations in the text and geologically coloured map of the Cheadle Coalfield. Price with map, 2*s.* (Preface dated 12th March, 1903.)

.—Summary of Progress of the Geological Survey of the United Kingdom and Museum of Practical Geology for 1902, with Introduction by J. J. H. TEALL, M.A., F.R.S., Director. 8vo; pp. iv and 240, with 9 illustrations in the text. London, 1903 (received 20th August, 1903). Printed for H.M. Stationery Office; sold by E. Stanford, London, etc. (or of Messrs. Dulau & Co., 37, Soho Square, W.). Price 1*s.*

HE Geological Survey memoirs recently published, whose titles we quote above, are of considerable interest.

1. The first of these is a continuation of "The Geology of the outh Wales Coalfield,"[1] comprised in Sheet 248, and is the fourth art of the memoir descriptive of this region, including the mportant part of the coalfield extending from Pontypridd on the ast to Cwmavan on the west, and from Aberaman and Glyn-corwg the north to Llantrisant and Mynydd Margam in the south, mbracing the greater part of the range of the best steam-coal.

Sir H. T. De la Beche, Sir W. E. Logan, and Mr. D. H. Williams ade the first survey of this area on the old map; probably most f the work was by De la Beche himself, but the western part was urveyed by Logan before his connection with the Geological urvey. The original maps were exhibited by Logan in 1837 at e British Association in Liverpool, and attracted the attention of e la Beche, with the result that they were handed over to the eological Survey and incorporated in the official maps, while ogan himself became a member of the staff. Sheet 36 was ublished in or before the year 1845.

The re-survey was made on the 6 inch scale, under the superntendence of Mr. Strahan, and published in 1899. The eastern art of Sheet 248 was surveyed by Mr. Strahan, the south-western art by Mr. Tiddeman, and the northern part by Mr. Gibson.

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[1] See previous review, GEOL. MAG., June, 1903, p. 269.

Each geologist contributes an account of the area surveyed by himself, and the whole memoir has been edited by Mr. Strahan.

Two subdivisions of the Coal-measures, namely, the Pennant series and the Lower Coal series, occupy nearly the whole area. In the latter occurs a group of seams which yield the well-known smokeless steam-coal. These seams are illustrated in the present memoir by a folding plate giving six vertical sections; various other sections are also given in the text, while sheets of vertical sections, Nos. 83–85, are published separately. The seams of the Lower Coal series vary greatly in thickness; thus, in the Aberaman Colliery in a section prepared by Mr. E. M. Hann (given in detail on pp. 12–14 of this memoir), in a depth of 283 yds. 1 ft., or 850 feet, no fewer than 28 seams are passed through having an aggregate thickness of 15 yds. 2 ft. 8 ins.; but of this amount only 4 seams are more than a yard in thickness, 5 are over 2 feet thick, 11 exceed one foot in thickness, and 8 are less than a foot; so that it is probable that not more than 9 out of the 15 yards in thickness of coal, if even so much, are won at this colliery. It may be of interest to notice that, though the seams can be recognized for long distances in an east and west direction, yet both these and the measures associated with them change so rapidly southwards that only a general correlation by groups is possible. In this part of the coalfield some massive sandstones, much resembling Pennant, develop in the upper part of the Lower Coal series.

The Pennant series shows a no less remarkable expansion both in a southward and westward direction. At the same time its upper part becomes split up by shales and coal-seams, which have yielded the bulk of the coal near Neath, Swansea, and Llanelly. Thus both the top and the bottom of the Pennant is less distinct than in Monmouthshire, where the subdivision consisted almost exclusively of sandstone.

The Upper or Llantwit Coal-measures occur in two small outliers only in the area comprised in Sheet 248.

In the South Crop, where the high dip usual in the southern margin of the coalfield prevails, the Millstone Grit and what may be the top of the Carboniferous Limestone come into view, but they are partly overspread by Triassic strata, which have been laid down unconformably upon their truncated edges. The Coal-measures themselves are partly thus covered, and it is worthy of note that the Triassic conglomerates consist, not of Coal-measure rocks, but of fragments of Carboniferous Limestone.

The Secondary rocks, which include Keuper, Rhætic, and Lias, are described in a separate chapter. They enter the map under description along its southern margin only.

The faults and disturbances are grouped into (1) the east and west folds and the Moel Gilau Fault, and (2) the north-north-westerly faults. They are discussed in detail in chapter viii.

Chapter ix, after giving a general account of the glacial deposits, deals with their occurrence in each valley. In chapter x the principal economic products of the region are enumerated.

nap (price 1*s.* 6*d.*), which is very carefully printed in colours, shed in two editions, on one of which (the Solid Edition) deposits and the like are omitted, while on the other (the ial Edition) such deposits are indicated by colour, as well portions of the solid geology which are not concealed by The map of the solid geology, being nearly all covered by l-measures, the symbol of which is an olive-green colour, ad and mournful effect, and renders it rather difficult to r the names of places upon it. We think it might be possible a somewhat paler colour with advantage. Manuscript six- ps geologically coloured are deposited in the Survey Office, Street, where they can be consulted, and copies can be l at cost price.

The Geology of the Cheadle Coalfield," by George Barrow, small but excellent memoir, complete in itself, of an outlying of the North Staffordshire Coalfield, full particulars being f the various seams of coal, with records of borings and on the probable extent of the workable Coal-measures. diagram-section across the coalfield is given on p. 49, the various workable coal-seams. There are 17 seams of o being 6 feet in thickness, three over 3 feet thick, seven t and upwards, and the remainder only about one foot in ss.

ls of the underlying Millstone Grit series and the overlying and Keuper formations are also furnished, and special e is made to the water-bearing strata. The Glacial Drift er superficial deposits are described, and the memoir is nied by a small but excellent colour-printed geological map, ve hope to see followed in the issue of every separate Survey

area described in this small memoir is remarkable for the t its main features are of two widely different ages. What broadly called the northern portion, is composed of Car- ous rocks, forming a sloping tableland essentially of pre- age, though modified of course by later denudation. Upon er land-surface the Triassic rocks were deposited, but have een denuded off all except a small portion of the northern us restoring, as it were, the old pre-Triassic surface. In thern area, however, these rocks have escaped denudation siderable extent, and now form a second and newer tableland, king the first and older one. The true form of the older d is somewhat obscured locally by the hill of red sandstone dle, but from the summit of the hill it is at once seen that lated eminence is simply a detached portion of the newer plateau, and really serves to emphasize the fact that these o form a tableland.

highest ground occurs in the northern area, formed of ferous rocks, attaining an elevation of 1,000 feet about s, and 800 feet in the neighbourhood of Wetley Rocks. assic rocks do not attain so great an elevation; at the edge of the plateau overlooking Cheadle the ground maintains a fairly uniform height of 700 feet above sea-level, and the top of the hill at Cheadle is at the same height.

The drainage of the area is effected by the two rivers the Churnet and the Tean and their branches. Of these the Churnet is much the larger, and flows for the most part in a deep valley, often almost a gorge; and so regular on the whole is the plateau on both sides of the river that it is often possible to look across the deep valley without realising its existence. The chief branches of the Churnet are three in number, and flow through the Consall Woods, the valley between Ipstones and Froghall, and the beautiful gorge of Dimmings Dale. The gorge is renowned for its steep, craggy, and densely wooded sides. It is cut in the Triassic rocks; the other two channels are in the Carboniferous. Though less gorge-like than Dimmings Dale they both have steep and craggy sides locally. The country about Cheadle is drained by small streams flowing in shallow hollows, which unite to form the Tean, and eventually flow into the Churnet to the south of this area.

Much of the ground is permanent pasture, and this is specially the case where the soil is formed of the heavy Carboniferous shales and clays. Of the lighter lands, formed of the sandstones and grits of this formation, a considerable portion is under the plough, and the same is true where the soil is formed of the dry Triassic sandstones. Even here, however, may be noted the same tendency to lay ground down in permanent pasture that is seen in many other parts of England.

Several minor industries are carried on in the district. Of these silk-spinning at Cheadle is mainly due to local cheapness of production; a manufacture of which the town of Leek may be taken as the centre. Brick-making is carried on to a considerable extent, the Coal-measure shales and clays being employed for this purpose. The bricks are of excellent quality.

There are large copper-works in the Churnet Valley close to the railway at Froghall and Oakamoor. The industry is still retained, although the original deposit of copper-ore at Ecton Hill which gave rise to it has been long since abandoned. There were also formerly brass-works near Cheadle which had a high reputation, but these have fallen into decay.

Coal-mining is the most important industry of the district, and gives employment to a considerable number of men. There are at present six collieries at work, but only two, the Foxfield and the Delphouse, are connected with a railway, so as to be able to send coal out of the district; the others can only supply local needs.

The coal-workings of this district are of great antiquity. They can be traced back as far at least as the reign of Richard III. The coal-seams outcrop at the surface, and, not being concealed beneath drift or Boulder-clay, were ploughed up in the fields, and so came to be early recognised and used as fuel. In the majority of cases the old workings for coal were started from the outcrop, and therefore required no great engineering skill to develop. They all appear to have been arrested by the influx of water into the workings, although in one instance they evidently displayed some considerable intelligence in draining a particularly good seam between Belmont Hall and Ipstones by driving a level to carry off the mine water.

3. The SUMMARY OF PROGRESS for 1902 conveys an excellent idea of the vitality of the Geological Survey, under its present able Director, Mr. J. J. H. Teall, F.R.S., whose zealous activity in planning the work is only equalled by the energy displayed by his staff in carrying it into execution.

In England and Wales the field-work has mainly covered four areas—Devon and Cornwall, South Wales, the Midlands, and the London district. In Scotland the work has been distributed over six districts, four being in the unsurveyed portion of the Highlands and two in the Carboniferous areas of the Midland Valley. In Ireland the Drift Survey was continued in the neighbourhood of Belfast. A few of the more important features of the work of the year may be referred to here.

Highland Metamorphic Rocks.—Probably the oldest rocks with which the Survey has had to deal in the course of the year occur in the Highland metamorphic region. Previous work in the areas occupied by the Eastern Highland schists in the north of Scotland have demonstrated the existence of extensive tracts of country composed of rocks closely resembling certain portions of Lewisian gneiss, especially those which occur in zones of secondary shearing. Those varieties of gneiss to which reference is made consist of alternations of acid and basic material, with occasional lenticles of ultra-basic rock; but they differ from the unmodified gneisses in possessing a granulitic structure. Two belts composed of rocks of this type have been met with by Mr. Hinxman in Strathconan Forest, Ross-shire, where they are seen to be most intimately interfolded with siliceous granulites of the Moine type. Although the exact meaning of these facts is not apparent, it may safely be predicted that they will be found to have a most important bearing on the origin of the Eastern Highland schists of Sutherland and Ross.

Other facts bearing upon the same subject have been observed by Mr. Clough in central Ross-shire, a granitic rock at some early period having been intruded into sediments which have been converted into hornfels by contact-action. Zones of thrusting and shearing comparable to those which have been described in the Lewisian gneiss traverse both the granitic area and that occupied by the altered sediments, the hornfels having, as a result, been converted into mica-schists, and the granitic rocks into finely foliated augen-gneisses, with a granulitic matrix.

Important observations have been made in the Southern Highlands by Dr. Peach and the officers acting under his direction, both on the mainland and the islands of Argyllshire.

The great quartzite formation of Islay and Jura, which has been split up into several recognizable zones, in some of which flattened worm-casts (*annelide-burrows*) occur, has been followed into Scarba, and evidence obtained that the boulder-beds, so well developed in the Isles of the Sea, form the natural base of this group of strata. These beds contain fragments, many of which are rounded, of the underlying Degnish and Shuna Limestones.

In the Eastern Highlands the characters and relative ages of the complex igneous intrusions have been studied, but this subject is still *sub judice.*

Torridonian.—The Torridonian rocks, as they are developed in Rum, have been described by Mr. Harker, who shows that they have been affected by the post-Cambrian thrust-movements. In the north-west of the island a prominent crush-breccia, composed of lenticles of Cambrian limestone and crushed sandstone, overlies the thrust-plane.

The detailed mapping of the *Lower Palæozoic rocks* on the north side of the Carboniferous area in South Wales has shown that the anticline in which the oldest rocks come to the surface follows the Towy Valley, and Messrs. Cantrill and Thomas have recognized an inversion which has had the effect of bringing the *Didymograptus bifidus* shales over the Llandeilo Beds.

Old Red Sandstone and Devonian.—Additional evidence of the fact that the lavas of Lorne plateau were poured out on an uneven surface formed of the Highland schists has been obtained in the course of mapping the southern margin of this plateau to the north of Loch Melfort, and definite proof of the Lower Old Red Sandstone age of the Glencoe volcanic rocks has been furnished by the discovery of *Psilophyton* in shales which are associated with the lavas.

In England the Old Red Sandstone rocks on the borders of the South Wales Coalfield have been examined, and evidence of a powerful strike fault, or rather series of faults, traversing the central portion of the northern band has been obtained. "The course of this disturbance," as Mr. Strahan says, "along the middle of the outcrop of the Old Red Sandstone for so many miles, its effect in throwing in patches of Carboniferous Limestone by what must be an enormous displacement, and lastly, the guiding influence which it has exerted upon the rivers, in common with other disturbances, of the east-north-east and west-south-west system, all combine to give it an unusual interest."

In North Cornwall the purple and green slates with *Pteraspis* which occur in Watergate Bay have engaged the attention of Mr. Reid. They are of special interest as indicating, both by their fossil contents and lithological characters, the existence of the Old Red Sandstone facies within the Devonian area.

The work of mapping the coalfields of England on the six-inch scale has been continued in South Wales and in the Midland counties, while in Scotland the work of revising the old six-inch maps has commenced. In South Wales the mapping of the coalfield proceeds steadily towards the west, and much information as to the correlation of the coal-seams and the nature of the disturbances will be found in this Summary of Progress. Three systems of faulting or folding exist. The steep uplift which determines the southern margin of the coal-basin and the Llanelly syncline belong to the pre-Triassic system, which traverses the Vale of Glamorgan. A long series of north-north-west faults, the course of which across the pre-Triassic folds has been worked out in detail, belongs to the system which is certainly in part of post-Triassic, but probably in part also of pre-Triassic age. Lastly, a series of parallel disturbances of great magnitude, which traverse the northern part of the coalfield, the Old Red Sandstone and the Lower Palæozoic rocks, and which have determined the river drainage, may be assigned to the system of which the Neath disturbance is a well-known example. This third system, which is characterized by folding and overthrusting on a large scale, runs in a general west-south-west direction, and from its remarkable influence on the surface configuration is believed to be of later date than the others.

In the Midland district the work has been confined to the southern and western part of the Derbyshire and Nottinghamshire Coalfield. Mr. Wedd has mapped out the various beds of Millstone Grit which were not separated in the original survey, and one result of his work has been to relegate a considerable tract of country which was formerly regarded as Coal-measures to the Millstone Grit formation. Mr. Gibson has continued his researches on the higher measures of this coalfield, and has obtained additional evidence to prove that beds above the Top Hard, which have been brought to light in the Gelding shafts and in the Thurgarton boring, are palæontologically, lithologically, and stratigraphically comparable with the higher measures occurring in other Midland coalfields. As he points out, there seems no escape from the conclusion that the Pennine elevation, with the consequent breaking up of the syncline, was subsequent to their deposition. He has also obtained evidence of the existence of marine conditions during the deposition of the Coal-measures at several horizons, both low down and high up in the series, and in view of these facts he naturally asks whether a much larger proportion of our Coal-measures has not been formed under marine conditions than is generally supposed. In working out the palæontology of the coal Mr. Gibson has received valuable aid from Dr. Wheelton Hind, whose name frequently recurs in this Summary of Progress.

In Scotland the revision of the Carboniferous areas has been commenced in the eastern part of the Midland Valley. Mr. Wilson has re-examined the oil-shale field to the west of Edinburgh, and calls attention in his report to the fact that the shales in that region, with few exceptions, deteriorate both in the quantity and quality of the oil as they are followed downwards. If this should prove to be a general law, it will obviously have a very important bearing on estimates of the value of any area in which the oil-shale horizons exist, and raise an interesting problem as to the nature of the processes by which the oil-producing compounds have been concentrated near the existing surface.

The examination of the coast between Dunbar and Cockburnspath has enabled Mr. Clough to prepare a detailed section of the Carboniferous Limestone series, and to show that the beds which dip under the sea along a portion of the coast are probably very near the base of the Edge coals of Midlothian. These coals may therefore exist beneath the sea under conditions which will enable them to be worked at some future time.

But the most striking addition to our knowledge of the Carboniferous rocks of Scotland is that furnished by Mr. Kidston's examination of a large suite of plants from the Canonbie Coalfield, in the collection of which he was assisted by Mr. Macconochie. This proves that Upper, Middle, and Lower Coal-measures are here present. According to Mr. Kidston the highest measures are on the horizon of the Radstock Beds, an horizon which is higher than any reached in the midland or northern coalfield so far as is at present known.

The Permian and Trias, the Jurassic and Tertiary deposits have also received attention during the past year, but we cannot now dwell with greater detail on the Summary before us, which deserves to be more fully studied by all who take an interest in the progress of geology in the British Isles.

CORRESPONDENCE.

COMMENTS ON A COMMENTATOR.

Sir,—As my name has been made prominent in more than one part of the last number of the Geological Magazine, permit me to say that I see no reason to modify what I said (1895, p. 75) about the Budleigh Salterton pebbles, and cannot admit that Mr. Shrubsole is right in asserting the oblate spheroidal form to have been acquired by rolling on the beach. To this point I paid particular attention, with what result may be seen in the following extract from my diary. After some notes on size, form, and colour, it goes on—"I think these peculiar, almost semicircular ellipsoids are rather commoner on the beach than in the cliffs, perhaps due to their being a little more worn and selected. Nevertheless, they are generally the dominant form in the sections, but are less conspicuous from being half buried." This flattened form could not be acquired by wave-action alone, but must be initiated by a certain original 'slabbiness' in the rock from which the pebbles have been derived. A parallel to this may be found in the flattened chalk pebbles on the beach in the Bridlington district. Thus the dominant quartzite pebbles at Budleigh Salterton must have come from a source different from that which has supplied most of those at Cannock Chase.

Reference is also made to a paper of mine on Luxulyanite. It is not easy to disentangle the writer's meaning from the mass of irrelevant matter, but I presume it is not meant to be complimentary, so I may say that though more than a quarter of a century has passed since I wrote this paper, and I have studied many tourmaline-bearing rocks in the interval, I have found no reason to alter the opinion then expressed as to the history and formation of this mineral in that case. I also am familiar with party-coloured crystals of tourmaline, but fail to see that their occurrence affects *the* accuracy of my original conclusions. I do not remember having anywhere stated that tourmaline could only be formed in the way which I had described in that particular rock.

Yet more, in regard to the occurrence of magnetite in cubes. With such very minute grains mistakes are more than possible, but I still think that I detect the solid angles of cubes as well as of octahedra, and at any rate submit that this reference to my statement is misleading—"So far as I am aware [this is] the only record of the occurrence of magnetite in cubes in Great Britain"—for I had stated distinctly that the rock which I was describing was not in its natural condition, but, as I said, a basalt which had been completely melted by Messrs. Chance. That fact ought not to have been suppressed.

T. G. BONNEY.

BRITISH GEOLOGICAL PHOTOGRAPHS.

SIR,—With reference to your most kindly article in the GEOLOGICAL MAGAZINE for September, I should like to be allowed to say a few words, in order to avoid the possibility of misunderstanding.

The published series of "British Geological Photographs" consists of platinotypes (mounted or unmounted) or lantern-slides, accompanied by letterpress, and is issued only to those who undertake to subscribe for the three issues (at least 20 photographs each) of which the publication consists. Sets cannot be broken, and it is not permissible to subscribe for one issue out of the three.

I have room at present for about 20 new subscribers for the three issues, and for 50 new subscribers my Committee would consider the advisability of reissuing the whole series.

The third issue, which I hope to publish within this year, will complete the publication; but the Committee are contemplating the possibility of issuing a supplementary series on the same terms. Such a series would endeavour to fill up gaps in the first series, would illustrate important phenomena a little more fully, and would also include the more uncommon features and phenomena. A certain number of subscribers' names have been received for this supplementary series, but not yet enough to warrant publication. For the descriptions which accompany the photographs and add so much to their value for scientific and teaching purposes, the Committee are indebted to a number of geologists, many of whom are not members of the Geological Photographs Committee.

W. W. WATTS.

HOLMWOOD, FOUR OAKS, SUTTON COLDFIELD.
September 7th, 1903.

OBITUARY.

WILLIAM H. CORFIELD, M.A., M.D., F.R.C.P., F.G.S.

BORN DECEMBER 14, 1843. DIED AUGUST 26, 1903.

WE regret to record the death at Marstrand, Sweden, of Professor William Henry Corfield, sanitary adviser to His Majesty's Office of Works, one of our leading authorities on Sanitary Science, and one who brought a sound knowledge of geological science to bear on that subject. He was born in 1843, and was educated at

Cheltenham Grammar School, Magdalen College, Oxford, University College, London, and the medical schools in Paris and Lyons. Among the appointments which he filled were those of Professor of Hygiene and Public Health in University College, London, honorary sanitary adviser to University College and Hospital, president of the Epidemiological Society of London, vice-president of the Sanitary Institute, and president of the Society of Medical Officers of Health. In 1866 he was elected a Fellow of the Geological Society. In 1868 he was appointed examiner for honours in the Natural Science School, Oxford, and he discovered the existence of lithodomous borings in the Aymestry Limestone, and "thus removed to an earlier age than had been previously known the evidence of boring bivalves." He was not only the first professor of hygiene appointed in London, but he started the first hygienic laboratory, which was at University College. For six years he was a member of and reporter for the British Association Committee on the treatment and utilization of sewage, and he originated, in 1891, the meeting of the International Congress of Hygiene and Demography in London. Among his publications are a "Resumé of the History of Hygiene," "Dwelling Houses: their Sanitary Construction and Arrangements," "The Laws of Health," "Disease and Defective House Sanitation," and other works.

We are indebted for most of the above particulars to the *Times* of August 27th.

EDWARD EATON WALKER, B.A.,

GEOLOGIST TO THE EAST AFRICAN PROTECTORATE.

A MOST promising career has been cut short by the death of Mr. E. E. Walker, on the last day of February, as the result of blood-poisoning.

Walker was a Scholar of Trinity College, Cambridge, and obtained a first class in Part I of the Natural Science Tripos in 1899, and again in Part II in 1900: in the latter year he was awarded the Harkness Scholarship.

He undertook the examination of a group of rocks in the English Lake District, and has left behind an account of the work, which, though incomplete, is in a state suitable for publication.

Early in 1902 he proceeded to East Africa, having been appointed Geologist to the Protectorate: his letters to his friends proved how keenly he worked there, and how congenial was the life to him. In February of the present year he was at work in the country to the north-east of the Victoria Nyanza, and there he died.

Walker was an ideal Englishman: able, strong, fearless, and modest, he was beloved by all who met him. Those who attended the "Long Excursion" of the Geologists' Association to Keswick in 1900 will remember the unassuming manner in which he explained a piece of work which he had done in the Langstrath Valley. His "Reports on the Geology of the East Africa Protectorate" have now been published officially. Had he lived he would have been in the front rank of geologists. But it was not to be so: he has died for his country.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. XI.—NOVEMBER, 1903.

ORIGINAL ARTICLES.

I.—Notes on some specimens of Straight-shelled Nautiloidea collected by the Rev. Samuel Couling, M.A., Ching Chow fu, Kiaochow, North China.

By G. C. Crick, Assoc.R.S.M., F.G.S., of the British Museum (Natural History).

(PLATE XXII.)

THE specimens, etc., upon which the following notes are based were sent from China by the Rev. Samuel Couling, M.A., to Dr. Henry Woodward, F.R.S., who has kindly permitted me to examine them. They consist of two examples displayed in longitudinal section upon the surface of two blocks of limestone, and photographs of three other examples, together with the rubbing of a fourth similarly preserved.

"The locality from which the fossils come is found in Richthofen's Atlas [von China], West Shantung plate, south of Tsing tshou fu, 36° 40′ N. Lat., 118° 40′ E. Long. The hills are marked Mittel and Ober Sinisch" (i.e. between Cambrian and Silurian in age).

The specimens belong to the straight-shelled Nautiloidea, and represent at least three distinct species.

One of these is indicated on the weathered surface of a slab of grey limestone by a longitudinal section showing a nummuloidal siphuncle, and, towards the posterior part of the specimen, three or four chambers. A length of about 95 mm. is preserved and is entirely septate; the shell apparently tapers very slowly; its greatest width is about 50 mm., the siphuncular elements here being about 24 mm. and the depth of the chambers 11 mm. Obstruction rings (*anneaux obstructeurs*) are well developed, contracting the central axis of the siphuncle into an annulated endosiphuncle with tubules radiating from the annulations. The openings of these tubules are well shown in several of the siphuncular elements at the upper part of the specimen. The relative proportions of this specimen resemble those of the posterior portion of Barrande's *Orthoceras docens*,[1] occurring in the Silurian of Bohemia, in Étage E, bande e_2, which is regarded as the equivalent of the Wenlock and Ludlow of this country (see Fig. 1). In that species the siphuncular elements decrease in diameter towards the body-chamber.[1] They appear to do the same in the present specimen, but this, I think, is due to the fact that the anterior part of the specimen is weathered down further from the median axis than the posterior part.

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[1] J. Barrande: Bull. Soc. Géol. France, sér. II, tom. xii, p. 453, pl. xii A, figs. 2, 3; and Syst. Sil. Bohême, vol. ii, texte iii (1874), p. 632, pl. ccl.

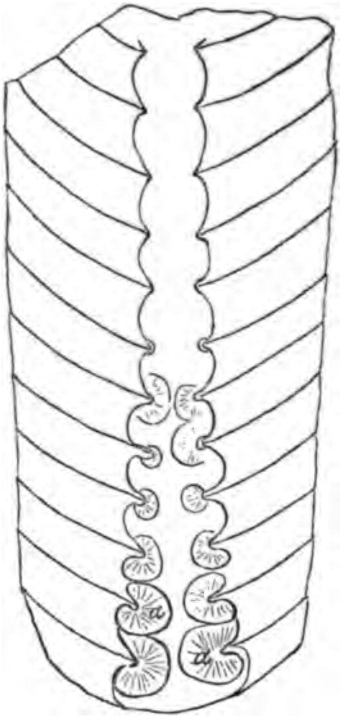

FIG. 1.—Longitudinal section of *Actinoceras* (*Paractinoceras*) *docens*, J. Barrande, sp. *a*, *a*, organic deposits upon the necks of the septa, forming obstruction rings (*anneaux obstructeurs*). Silurian (Étage E, bande e_2): Dworetz, Bohemia. (After Foord.)

The specimen may, I think, safely be referred to Stokes's genus *Ormoceras*,[2] a genus confined to the Ordovician rocks of North America and now regarded as a subgenus of *Actinoceras*;[3] and I would suggest that it is nearly allied to Hall's *Ormoceras tenuifilum*,[4] a common species in the Black River Limestone (Ordovician) of New York State.

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[1] Foord (Cat. Foss. Ceph. British Museum, pt. i, 1888, p. 208, fig. 32) referred Barrande's species to Hyatt's genus *Sactoceras* (Proc. Boston Soc. Nat. Hist., vol. xxii, 1883, p. 273), but Hyatt himself, in Eastmann's translation of Zittel's "Textbook of Palæontology" (p. 528, fig. 1080), refers the species to *Paractinoceras*, a new subgenus of *Actinoceras*.

[2] C. Stokes: Trans. Geol. Soc. [2], vol. v, pt. 3 (1840), p. 709.

[3] A. Hyatt in Eastmann's Translation of Zittel's "Textbook of Palæontology," vol. i (1900), p. 528.

[4] J. Hall: Nat. Hist. New York, pt. vi, Palæontology, vol. i (1848), p. 55, pl. xv, figs. 1*a*–*c*; pl. xvi, figs. 1*a*–*e*; pl. xvii, figs. 1*a*, *b*. See also J. Barrande: Syst. Sil. Bohême, vol. ii, pl. ccxxxvii, figs. 5–7.

The original of Fig. C in our Plate XXII is referable to the same genus, and possibly also to the same species.

It is of interest to mention that the matrix contains several small Brachiopods respecting which Mr. Buckman (who kindly examined them at Dr. Woodward's request) says, "The general appearance suggests *Orthis* (*Dalmanella*) *testudinaria*, Dalman, an Ordovician species."

A second species is represented by a photograph of a section of a fragment (Plate XXII, Fig. B), and a rubbing of another specimen about 25 centimetres long, displayed in section on the surface of a slab. Although the relative proportions of the parts of the shell—the relatively wide siphuncle and the very shallow chambers—agree fairly well with those of *Actinoceras imbricatum*, Hisinger, sp.,[1] from the Silurian (Upper Ludlow) of the Island of Gothland, Sweden (see Figs. 2*a*–*c*), it seems scarcely likely that an example of this species could be so worn down as to expose the siphuncle for a length of 25 centimetres. I therefore venture to suggest that the specimen may belong to Hall's genus *Gonioceras*,[2] which at present is known only from the Ordovician rocks of North America, and possibly also from Norway (see Figs. 3*a*, *b*).

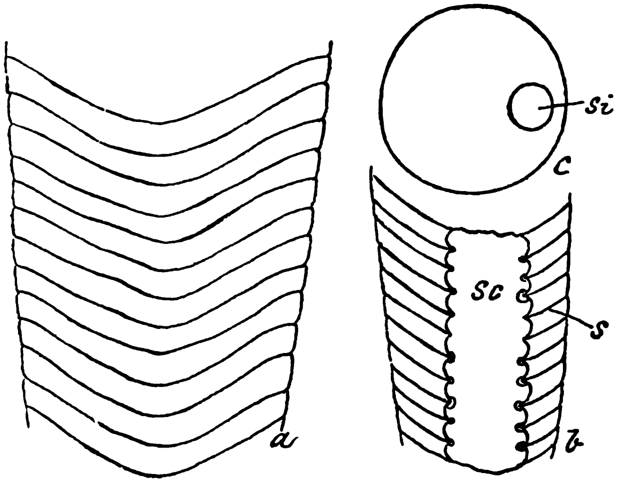

Fig. 2.—*Actinoceras imbricatum*, Hisinger, sp. *a*, fragment of a cast, showing the disposition of the septa on the siphuncular aspect; *b*, section of a smaller individual, showing the large nummuloid siphuncle *sc*, and the septa *s*; *c*, transverse section, showing the position of the siphuncle (*si*) and its diameter between the necks of the septa. *a* and *b* of the natural size; *c*, reduced half. Silurian (Upper Ludlow): Island of Gothland, Sweden. (After Foord.)

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[1] Hisinger: Anteckn. i Physik och Geognosie, Häft. v, p. 112, tab. iv, fig. 4. See also A. H. Foord, Cat. Foss. Ceph. British Museum, pt. i (1888), p. 180, fig. 24.

[2] Nat. Hist. N. York, pt. vi, Palæontology, vol. i (1848), p. 54.

In this genus the shell is much compressed, the chambers shallow, the test thin, the siphuncle nummuloidal and placed near one surface. According to Hall this fossil occurs in the Black River Limestone (Ordovician) in New York State, "usually appearing upon the weathered surface of rocks, with the ventral or dorsal side exposed, and presenting a broad surface with extended septa and central siphon."

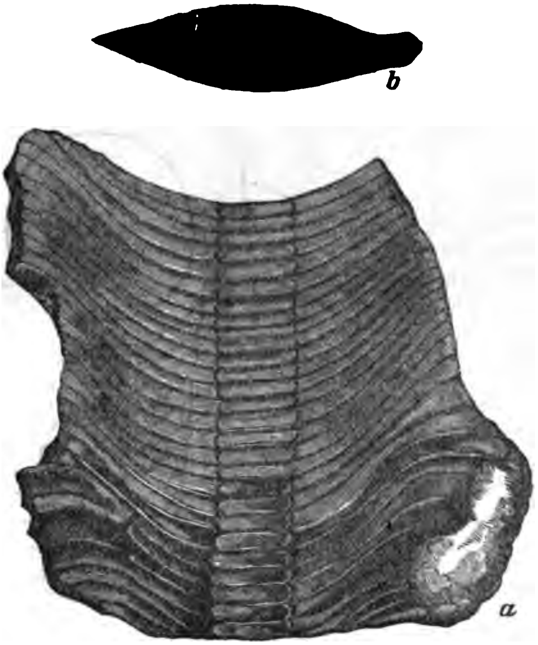

Fig. 3.—*Gonioceras anceps.* *a.* Much weathered fragment, drawn from a specimen in the National Collection (No. C 4079); natural size. *b.* Section showing position of siphuncle. Ordovician (Black River Formation): Watertown, Jefferson County, New York State. (After Foord.)

A third species, in a totally distinct matrix, is represented by a broken portion of a longitudinal slab or polished section of the well-known *Orthoceras chinense*, Foord,[1] of which the British Museum contains several excellent examples. *Orthoceras chinense*, Foord—the true 'Pagoda-stone' of the Chinese—appears to be a well-marked species from the Devonian of China, and as it is much sought after for cutting and polishing in order to be mounted and form ornamental screens or panels, it has become an article of commerce, and consequently may now be met with in almost any part of China. The name 'Pagoda-stone,' which is generally given to the cut and polished sections of *Orthoceras chinense* by the Chinese, is said to arise from the popular belief that they are formed in the earth wherever the tower of the pagoda casts its shadow upon the ground.

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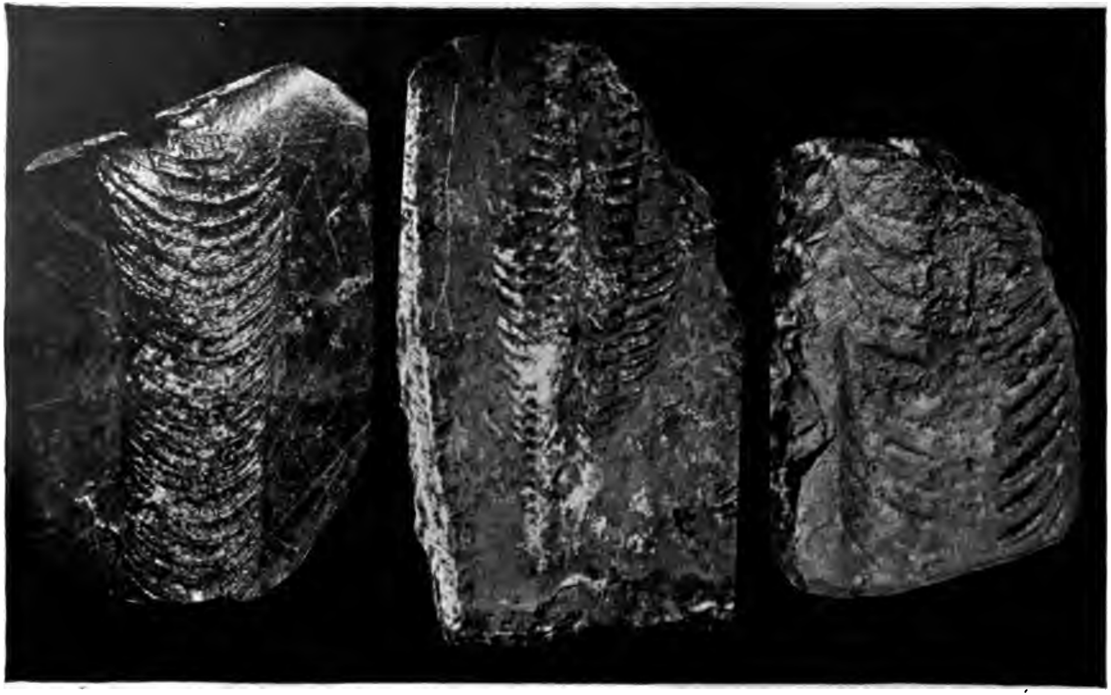
[1] A. H. Foord: Cat. Foss. Ceph. Brit. Mus., pt. i (1888), p. 100.



A B C

Palæozoic Nautiloidea from the Province of Shantung, North China.

The first examples were described by the late Dr. S. P. Woodward, '.G.S., formerly of the Geological Department, in 1856 (see Quart. ourn. Geol. Soc., 1856, vol. xii, pp. 378–381, pl. vi), from two pecimens in the British Museum obtained by Wm. Lockhart, Esq., '.R.C.S., in Shanghai, from some place 200 miles distant, and given) Mr. Daniel Hanbury, of Plough Court, Lombard Street, who ubsequently presented them to the British Museum in 1854. The ırger example, a polished section, measures 29 inches in length nd 4 inches in its greatest diameter; the other measures 18 inches ı length. Another well-preserved specimen 9 inches long (also xposed in section and polished) was obtained from the Devonian f the interior of the Province of Kwang-tung, South China, by the Ion. Robt. Marsham, who presented it to the Museum in 1877. 'wo slabs of the same *Orthoceras chinense* were obtained in hanghai and presented by R. Swinhoe, Esq., H.B.M. Consul in 'ormosa, in 1870. Mr. Swinhoe's specimen is of interest as it ıows two slices of the same *Orthoceras* having a distorted siphuncle, malformation which must have been caused by some injury ıstained during the lifetime of the animal. Two other fine slabs, ıid to be from the Devonian Limestone of Ichang, in the Province f Hu-pe, Central China, and to the north of Kwang-tung, were resented by J. Walters, Esq., H.B.M. Consul at Ichang. The above ɜven specimens are all cut and polished sections, the matrix of which ı also the same, namely, a rich reddish-brown or chocolate-coloured mestone. The last example is the shell of a very large *Orthoceras* ıinense, *preserved in the round* and extracted from the matrix; it is ɔove 4 feet in length. This specimen was procured by N. M. 'ankowsky, Esq., from the Devonian Limestone 30 miles north of ɔhang. This limestone is thus fixed as to two localities in China, amely, the Province of Kwang-tung and that of Ichang, the ıthorities for which are, I think, quite reliable. The other ɔecimens from Shanghai were probably purchased in the bazaars.

The two former species appear to be of Ordovician age, whilst ıe third is considered to belong to the Devonian. It is somewhat ɔubtful whether the latter (which has been cut and polished) was btained from the same locality as the other fossils.

Pl. XXII, Fig. A may represent an *Orthoceras* or an *Actinoceras*, ut its affinities are very doubtful.

I am indebted to Dr. A. Smith Woodward, F.R.S., for permission ı use the woodcuts illustrating this article.

EXPLANATION OF PLATE XXII.

A. *Orthoceras* or *Actinoceras*.
B. *Gonioceras* sp.
C. *Actinoceras* (*Ormoceras*) aff. *tenuifilum*, Hall.

From the Ordovician (?) rocks south of Tsing tshou fu, Province of Shantung, orth China. Collected by the Rev. Samuel Couling, M.A., English Baptist ission to North China, Ching Chow, Kiaochow, China, who has presented the ıecimens to the British Museum (Natural History).

II.—On the Carboniferous Ichthyodorulite *Listracanthus*.

By Arthur Smith Woodward, LL.D., F.R.S., of the British Museum.

THE problematical fish-spine, *Listracanthus*, has already been found in the English Coal-measures;[1] but neither the specimens from this country nor the earlier discoveries elsewhere are sufficient to show the exact nature of the fossil, or even to determine its complete form. Two groups of remains of this spine, recently discovered by Mr. John Ward, F.G.S., in the Middle Coal-measures of North Staffordshire, are therefore of much interest as tending towards a more satisfactory knowledge of its characters.

One of the new groups just mentioned is preserved in the middle of a nodule, and probably comprises the remains of a single fish, though there is no clear outline of a body. Portions of at least 70 spines of *Listracanthus* are scattered through the fossil in an entirely irregular manner, and they are mingled only with smaller dermal tubercles, without any indication of bones or cartilage. So far as they can be observed, all the spines appear to be nearly similar in size and shape, and their principal features are indicated by the fragments represented in the accompanying Figs. 1–3. A generalised restored sketch of a complete spine is given in Fig. 4. They are all encrusted with a very thin film of pyrites, and their dark brown substance (presumably vasodentine) is so brittle that it is usually more or less flaked when uncovered by the hammer. Each spine is a thin, solid lamina, which seems to be bilaterally symmetrical, tapers a little towards the apex, and is slightly arched either backwards or forwards. The straight base-line is oblique with respect to the long axis of the spine, and its extent equals about one-fifth of the total height. Each lateral face is flat and marked by nearly parallel, vertical ridges, which are twelve to fourteen in number at the base, and are gradually reduced by terminating in succession at the sharp anterior and posterior borders. At the concave border the upper end of each ridge is produced into a short, straight, pointed denticle; and the interval between every two denticles thus formed is occupied by a similar point arising independently. Fewer ridges terminate at the convex border, which seems to have been quite smooth and regular, without denticles except near the apex, where they are few and inconspicuous. The apex is not pointed, but comprises a little cluster of sharp denticles, which are partly formed by the ends of the lateral ridges, partly independent and intercalated. The ridges are very delicate and sharp throughout, quite smooth, of uniform thickness, and separated by comparatively wide, smooth interspaces. As shown by a transverse section of the spine (Fig. 5), the ridges of the two faces are usually not opposite, but alternating. The ornament terminates very close to the base-line, so that the inserted portion of the spine is insignificant, and it is scarcely expanded.

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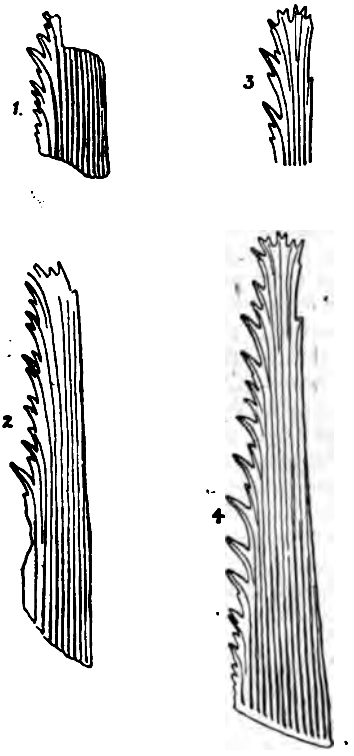
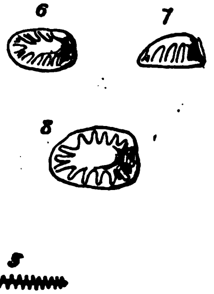
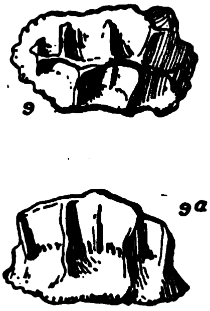
[1] H. Bolton, "On the Occurrence of the genus *Listracanthus* in the English Coal-measures": Geol. Mag., Dec. IV, Vol. III (1896), pp. 424–425, with Figure.

The dermal tubercles associated with these spines are even more numerous than the latter, especially at one end of the group, and they are of the form known as *Petrodus*. They are solid, and consist of very porous vasodentine. Their basal face is flat, and when viewed from this aspect they are observed to be usually oval or ovoid in shape, rarely circular. They are irregularly conical, and their height is less than their longest basal diameter. Their apex is smooth and rounded, and their sides are crimped by a few







FIGS. 1–8.—*Listracanthus Wardi*, sp. nov.; three times nat. size. Middle Coal-measures, Smallthorne, North Staffordshire. (Collection of John Ward, Esq., F.G.S., Longton.)
1. Base of spine.
2, 3. Middle and terminal portions of spines.
4. Restored drawing of spine.
5. Transverse section of spine.
6, 7. Tubercle, upper and lateral aspects.
8. Larger tubercle, upper aspect.

FIG. 9.—*Petrodus acutus*, Newb. & Worth.; upper aspect and lateral aspect (9*a*) of tubercle, 2¼ times nat. size. Carboniferous Limestone, Mjatschkowa, Moscow. (Brit. Mus. No. P. 5,117.)

large, smooth, radiating ridges, which terminate close to the basal edge, leaving a very small margin for insertion in the skin. The basal diameter of the largest tubercles is about equal to the basal extent of the associated spines; and there are no gradations between the two series of structures.

In part, at least, of the group just described *Listracanthus* is nearly as abundant as *Petrodus*; but in the second specimen discovered by Mr. Ward there is only one imperfect spine among the numerous tubercles. These tubercles, in comparatively soft shale, are especially well shown, and two of the best examples are represented in Figs. 6-8. It will be observed that their highest point is not central but displaced towards one end of the ovoid.

From the new specimens it is evident that *Listracanthus* is a strangely modified dermal tubercle, occurring in considerable numbers on part at least of the head or trunk of the fish to which it belonged. There can also be no longer any doubt that some varieties of the so-called *Petrodus* form part of the same armature, as already suspected from discoveries in the Coal-measures of Indiana, U.S.A.[1] Although, indeed, there are no gradations between the associated spines and tubercles in the specimens now described, one of the Russian Lower Carboniferous varieties of *Petrodus* (Fig. 9) is essentially a squat *Listracanthus* with deepened lateral ridges and an exaggerated basal expansion. The so-called *Petrodus acutus*, from the Coal-measures of Illinois,[2] is obviously similar. The two forms of dermal appendage under consideration are thus merely extreme modifications of one and the same type. It is, however, quite possible that some of the Carboniferous tubercles named *Petrodus* belong to fishes of quite another genus; for the typical *Petrodus patelliformis* is remarkably similar to the dermal tubercles of *Hybodus*, and may well have belonged to an ordinary Hybodont shark.

This uncertainty as to the relationships of the various tubercles known as *Petrodus* (M'Coy, 1848) renders it advisable to continue the use of the comparatively modern generic name *Listracanthus* (Newberry & Worthen, 1870) for the remarkable fossil here discussed. Judged both by the peculiar spines, and also by the tubercles, Mr. Ward's specimen represents a hitherto unknown species, and it may be termed *Listracanthus Wardi* in honour of its discoverer.

It is interesting to note that, like the spines of *Listracanthus* described by Mr. Herbert Bolton from the Lancashire Coalfield, this new species was obtained from a truly marine band of the Coal-measures. It was found in the shale underlying the Twist Coal, Nettle Bank Colliery, Smallthorne.

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[1] J. S. Newberry: Rep. Geol. Surv. Ohio, vol. ii, pt. 2 (1875), p. 56.

[2] Newberry & Worthen: Palæont. Illinois, vol. ii (1866), p. 72, pl. iv, fig. 17.

III.—The Hypostomic Eyes of Trilobites.

By W. K. Spencer, B.A., F.G.S. (Burdett-Coutts Scholar in the University of Oxford).

PROFESSOR LINDSTRÖM[1] in a recent paper has described sense organs discovered by him on the hypostome of very many genera of Trilobites. His description is as follows:—"In the plurality of species there are two tiny patches or maculæ, sometimes elevated above the surrounding surface like tubercles, and so they have also been called by some authors. But I have preferred to use the name 'macula' for them, as the plurality does not form tubercles. They are generally smooth and glossy, and situated next to the anterior groove, either above it or in it, at a regular distance from each other and the lateral margins. They may form a sunk spot, or, as commonly, an ovoid or elliptic area surrounded by a linear elevated border." "Common for a great number of maculæ in various groups, whether they show any organic structure or not, is the excessive thinness of their shell in comparison with that of the surrounding hypostoma. This is also in accordance with the tenuity of the cephalic eyes in relation to the test of the cheeks."

Beyond the "excessive thinness of their shell" the maculæ of the various genera show scarcely any constancy in their structure. A section through the macula of *Bronteus* shows distinct traces of lenses on the anterior apex (Fig. 2). "Only in the Asaphidæ, in *Illænus* and *Lichas*, the entire macula shows this structure. Perhaps, to judge by certain indications in *Bronteus*, once in a larval or preceding stage of evolution the whole surface of the macula was also in that genus covered with lenses, which have been reduced."

In other genera, e.g. *Bumastus* and *Nileus*, there is no trace whatever of any structure. "There is even in the same genus so great a variability that species with structure in the macula occur along with those devoid of any structure, or also, as in *Lichas*, with a different structure."

A great diversity in position may also occur. In *Phacops* and *Acaste* the maculæ are high up on the hypostoma, near its anterior margin.

The great variability in structure and position, together with the obvious stages of reduction, teaches us that the 'hypostomic eyes' of Trilobites are in a degenerate condition. My object in writing this paper is to show their close correspondence with certain sense organs present in the Phyllopod genus *Branchipus*, and also in *Limulus*. In *Branchipus* there occurs, ventral to the brain and just anterior to the hypostome, a median organ which Claus[2] has called the 'Kolbenzellen' organ. This consists of a number of nests of cells. Each nest (Fig. 3) has secreted a rhabdom, just as occurs generally in the compound eyes of Arthropods. Although it is median and unpaired in *Branchipus*, yet an exactly similar organ described by Patten[1] in his account of the development of *Limulus* possesses a paired origin. The paired 'Anlagen,' however, afterwards fuse and take up a median position. There is no doubt that if the development of the 'Kolbenzellen' organ of *Branchipus* were followed it would also have a paired origin.

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[1] G. Lindström, "Researches on the Visual Organs of the Trilobites": Kong. Sv. Vet.-Akad. Hand., B. xxxiv, No. 8.

[2] C. Claus, "Untersuchungen über die Organisation und Entwickelung von *Branchipus* und *Artemia*": Arb. aus dem Zool. Inst. in Wien, vi (1885).

FIG. 1.

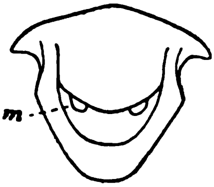
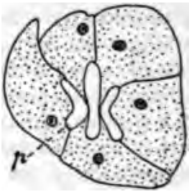


FIG. 3.



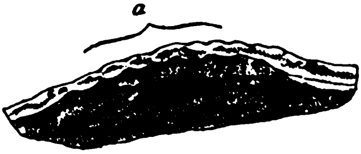


FIG. 2.

FIG. 1.—Hypostoma of *Bronteus*. After Lindström. *m* = macula.
FIG. 2.—Vertical section of macula of *Bronteus polyactin*. Sixty times nat. size. After Lindström. *a* = lenses.
FIG. 3.—Group of cells from the 'Kolbenzellen' organ, showing their ommatidia-like arrangement. *r* = rhabdom.

The 'Kolbenzellen' organ present in both *Branchipus* and *Limulus* represents a degenerate pair of compound eyes.[2] Their situation and structure allow them to be compared to the hypostomic eyes of Trilobites. In the living groups, however, they are in a more retrogressive condition than in Trilobites. They never show any trace of lenses, and in late development fuse and sink beneath the ectoderm.

Patten, in a discussion of the homologies of the 'Kolbenzellen' organ in *Branchipus* and *Limulus*, thought that the homology of these would furnish very strong evidence of the common ancestry of Crustacea and Arachnida in the Trilobites. We see that the hypostomic eyes of Trilobites, which were of course unknown to Patten, offer no support for this suggestion. They are already in a degenerate condition, and are inherited from some ancestor which may very possibly have been an ancestor of the Arthropod group in general. Patten wrote before the publication of the work of Beecher and our consequent true understanding of the Crustacean affinities of Trilobites.[1] Further, the discovery of the uniform occurrence of anterior chelate appendages throughout the Merostomata removes the points of resemblances which were formerly urged between the fossil allies of *Limulus* and the Crustacea, for it can no longer be argued that the first appendages of these were antenniform. Palæontological evidence has thus widened the gap in two directions, on the one hand by assigning the Trilobites definitely to the Crustaceans, on the other by showing the unity of the Merostomata. The embryological evidence of the Trilobite affinities of *Limulus* is also very weak. The young *Limulus* in the so-called 'Trilobite' stage possesses no true biramose appendages, at any rate on the cephalon, although a sense organ on the sixth pair has been described as an exopodite. The appendages of the cephalon are seven pairs, not the five pairs so characteristic of Crustaceans. The Arachnida and Crustacea have always been distinct groups, and must have been differentiated in pre-Trilobitan times.

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[1] Patten, "On the Morphology and Physiology of the Brain and Sense Organs of *Limulus*": Q.J.M.S., July, 1893.

[2] W. K. Spencer, "Zur Morphologie des Centralnervensystems der Phyllopoden nebst Bemerkungen über deren Frontalorgane": Z. für Wiss. Zool., lxxi, 3.

It has been suggested that Trilobites had much the same manner of life as *Limulus*. The fact that so few Trilobites have been found which show any trace of appendages militates against this view. We know Trilobites such as *Isotelus megistos*, or even *Paradoxides Davisii*, which are of very considerable size. If these had had legs stout enough to walk with, some trace must have been observed. Beecher has shown from positive evidence that the legs of *Triarthrus* are of extreme tenuity. We must assume, therefore, that the appendages of Trilobites were incapable of affording support for walking, and they must have been swimming appendages. Burmeister[2] long ago demanded for Trilobites a mode of life similar to that of the Phyllopoda. He observed that the remains of Trilobites were almost always found on their back. Beecher[3] observed the same, and remarked with regard to *Triarthrus Becki* that the material shows both legs and antennæ extended on both sides of the body in a very life-like position. This was a feature incompatible with the view of Walcott that Trilobites lived with the ventral side down, and the accumulation of gases in the viscera during decomposition overturned the animals; for this would lead to great displacement of the appendages. The ventral food groove, identical in appearance with that of Phyllopods, leads to the same conclusion. The Phyllopods appear to feed by turning over whilst swimming and seizing with their more posterior appendages a little mud which swarms with Infusoria, etc. This mud is then pushed along the ventral groove into the mouth. Casts of the intestines of Trilobites are still found filled with the mud acquired in this manner. The hypostome is obviously of great service in guiding the food in the proper direction, and this may account for its great development in Trilobites. The small size of the masticatory appendages, as in Phyllopods, would also support this view.[1]

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[1] See H. Woodward, Quart. Journ. Geol. Soc., li (1895).

[2] Burmeister: "Die Organisation der Trilobiten aus ihren lebenden Verwandten entwickelt"; Berlin, 1843.

[3] Beecher, "On the Structure and Development of Trilobites": Amer. Geol., xiii (1894).

The pygidium may have been of considerable assistance as a tail fin, and its increased size in post-Cambrian times would thus be accounted for.

This comparison does not claim, however, that the Trilobites have near affinities with the Phyllopoda, only that Trilobites had a Phyllopodan mode of life. The Trilobites are the most primitive Crustaceans known, the Phyllopoda are the most primitive Entomostraca. Nearer than this we cannot at present go.

IV.—Some Further Remarks on Granite: a Reply.

By Lieut.-General C. A. McMahon, F.R.S., F.G.S.

After the expiration of twelve months, Mr. A. R. Hunt, who was present at the meeting of the British Association at Belfast, has published in your September number a criticism on my address. His paper deals with a variety of matters with which I need not concern myself. His remarks on tourmaline have reference to another author, and not to anything I have written on that subject. He also passes strictures on what he calls "incidental geology," but as he includes Lord Kelvin and Canon Bonney with me in his condemnation, I can only congratulate myself on being in such good company.

In the following observations I shall confine myself to the criticisms on my Belfast address, and as Mr. Hunt tells us (p. 403) that the whole object of his paper "is to discuss General McMahon's incidental remark—'the beryl is crowded with liquid and gas cavities, the former containing movable bubbles and deposited crystals as well as water,'" I shall begin by considering the author's remarks under this head.

Before proceeding further it will be as well to correct an inaccuracy into which the author has fallen. On p. 393 he quotes me as stating that "beryl was the first [mineral] to crystallise, at a temperature approaching 1,200° C." This is a mistake. I certainly said that beryl was the first mineral to crystallise out of the magma, but I nowhere ventured to give the temperature at which that or any other mineral of the granite began to crystallise. I do not think we possess at present sufficient data to enable us to give with any approach to accuracy the temperatures at which the several minerals contained in a granite crystallise, and I did not attempt this task. I was dealing in this portion of my address with contact metamorphism, and my object being to impress upon my hearers the potential energy of a granite in a molten or fluid condition, I thought it desirable to consider "the probable temperature reached" by the Satlej granite.

After considering the melting-points of various granitic minerals, and after stating that the case was complicated by the fact that the presence of water at high temperature and alkali lowers, and pressure raises, the melting-point, I said that "if we consider the melting-points of the mineral constituents of granite we can hardly avoid the conclusion that for the magma to have attained perfect fluidity it must have reached a temperature of at least 1,200° C." I went on to consider, in order to strengthen the above view, Vernadsky's conclusions that kyanite is transformed into sillimanite, a well-known product of contact metamorphism, at a temperature of 1,320° to 1,380° C., and referred to Mr. George Barrow's observations in the Highlands of Scotland on the sillimanite zone between the kyanite and the granite. I also drew attention to his conclusions that the granite that had produced this contact metamorphism must have reached a higher temperature than that given by Vernadsky. 1,260° C., it will be observed, was the estimate I gave of the temperature probably reached by the Satlej granite when in a state of aqueo-igneous fusion. The question of the temperature to which the magma had fallen before the minerals began to crystallise out, is a totally different one. I did not venture to estimate this temperature in degrees of the Centigrade thermometer, but said generally that the magma must have been above the red-heat. There is a wide margin between 1,200° C. and 550° C. (red-heat). When I said that beryl was the first of the granitic minerals to crystallise, I did not imply that it began to crystallise at a temperature of 1,200° C. All that I affirmed regarding it was that it began to crystallise before the mica, felspar, and quartz which formed upon it, and whilst the magma was sufficiently fluid and mobile to allow the mineral to crystallise in its proper crystallographic form, without being "interfered with or molested by other solid minerals," "during the entire period of [its] crystallisation." Mr. Hunt apparently wishes to detract from the force of the evidence referred to above, namely, of the mica, felspar, and quartz having crystallised upon the beryl, by remarking that muscovite and quartz are minerals that are found in schists, and that they are sometimes formed at low temperatures, and he cites Fouqué & Levy to show that quartz may be formed at a temperature of 200° C. This argument, however, does not apply to the Satlej granite described by me.

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[1] Bernard, T.: "The Apodidæ," 1892, Macmillan & Co. Quart. Journ. Geol. *Soc.*, L (1894).

All petrologists are aware that some silvery micas and quartz can be formed in what Bischof terms the 'wet way,' at comparatively low temperature, but it is material to note that the Satlej granite is not a metamorphic, but is an undoubtedly igneous eruptive rock. As described in my paper, it cuts boldly across the Tertiary gneissose granite of the Himalayas. The intruder, though probably also a rock of Tertiary age, is of considerably later date than the foliated rock invaded by it. It is not only the latest intrusive rock in that part of the Himalayas, but it must have been erupted after the strains and stresses of earth-movements had ceased to operate on the rocks in that locality, for it does not itself contain the slightest appearance of foliation.

In my address I stated that the temperature of the Satlej granite "must have been above that of red heat," and I went on to remark that "the potential energy of water held in a fluid state by pressure must have been great. When, therefore, in the course of the earth-movements which accompany or in some cases are caused by the intrusion of eruptive igneous masses, pressure was temporarily relieved by the rupture and faulting of rocks, the superheated water contained in the magma was ready to flash into steam with almost explosive violence."

Mr. Hunt calls attention to the expressions used in the above passage that water was held in a fluid state by pressure, and he also refers to expressions used in other passages in my address, where I speak of water at a red heat, and considers that the views indicated by these expressions are not only inconsistent with the old physical theory of granite, but entirely subversive of them. I will take the first remark objected to into consideration before proceeding to the other.

In his previous paper on vein-quartz (GEOL. MAG., May, 1903, p. 212) Mr. Hunt reminds us that Dr. Sorby in 1876 estimated the critical temperature of water to be 412° C., but that Professor Hartley in 1877 estimated it at 342° C., which latter figure Mr. Hunt accepts as the true one. From Mr. Hunt's own showing, therefore, a margin of at least 242° C. exists between the boiling-point of water, 100° C., and the critical temperature, 342° C. It follows, then, that throughout a range of 242° of Centigrade temperature water must be held in a fluid state in the molten magma by pressure, so that for this range of temperature, at all events, the expression used by me is strictly and literally true. As regards the phrase water "at or above a red heat," I was following so good an authority as Scrope, who, as quoted in my address, speaks of "red-hot water or steam in a state of extreme condensation and consequent tension." When I spoke of water being at or above a red heat (550° C.) I thought experts would understand that I had water in a gaseous state in my mind. For the purposes of my argument the clearer the fact was realized by my hearers that we were considering water in its gaseous state, the better for my purpose, which was to impress upon them the potential energy and the kinetic motion exercised by water at this heat.

At the commencement of my address I warned my hearers that, the time at my disposal being brief, I would use great simplicity of language, free from technicalities. I wished to avoid, therefore, a dissertation on such elementary topics as the critical temperature of water, and of water existing in three states as a solid, a liquid, and a gas, and to confine the attention of my audience to the consideration of the potency and energy of a molten granite intruded into other rocks, and thought that any digression to consider objects outside the central idea of my paper would have put it a little out of focus.

If an artist has painted a landscape with the intention of drawing attention to the beauty and poetry of Nature as exhibited by various forms of rocks and foliage with fleeting lights and shadows, it would ruin the broad effect of his picture to introduce into his foreground, as I have sometimes seen, the figure of a sportsman firing at a duck or pheasant, and the bird falling to the ground with a broken wing and with feathers scattered in the air. The majority of those who examine such a picture would altogether overlook the beauty and poetry of the landscape, and would carry away the idea that the object of the artist was to illustrate the cruelty of sport. I think that some scientific writers labour under a want of the artistic sense. They leave their meaning obscure, not only by the want of lucidity of mind, but by scattering the attention of their readers, by diverting them to subjects beside the real point at issue. To prevent any further misapprehension I may mention that I abstained for a similar reason from entering into the question of what is implied by water being held in solution by granite.

Ostwald, in his remarkable work on solutions, has enlarged upon the theory that a substance in solution is split into its ions. This theory has, I think, been accepted as a good working hypothesis by the majority of chemists, as it clears up many points not otherwise capable of explanation. According to this theory water held in solution by a molten granite would be split into its ions, hydrogen and oxygen, and questions regarding the critical point of water would be held in abeyance during the time it was so held in solution. As, however, I did not, for the sake of simplicity, treat the subject in my address from the ion point of view, I will not attempt to do so now, but shall be content to regard the water in a granite above the critical temperature, as water in its gaseous state, though it must be remembered that if we regard it as a gas we must accede to it the kinetic energy and motion proper to a gas at a high temperature.

Mr. Hunt in his paper has come to the conclusion that "ordinary granites crystallised about the critical temperature of water," and in his paper on vein-quartz above referred to he records his conviction at p. 214 that "Fluid inclusions with deposited crystals are clear proof that the fluid was entangled in the quartz or other mineral, under 342° C." This conclusion or rule appears to me to be based on two assumptions, both of which I think erroneous. The first is that water enclosed in the minerals of an igneous rock was enclosed after it had assumed a fluid state. The second follows naturally from this, namely, that the mineral which enclosed the fluid water must have crystallised below the critical temperature. The main fallacy which underlies the above rule seems to me to have arisen from Mr. Hunt's failure to realise the possibility of molecules, on their coming together to form a crystal, bringing down entangled with them the molecules of a gas. My critic's conclusion is irreconcilable with the facts stated in my Belfast address, hence possibly his anxiety to discredit my facts under cover of an attack on the views expressed by me.

I have been led by the evidence supplied me by the study of thin slices to believe that the crystallisation of minerals in a plutonic rock, such as granite, was a slow and gradual process. I do not see how we can avoid this conclusion in the case of large porphyritic crystals of felspar, which in some places on Dartmoor attain a length of from three to four inches. I also referred to zonal crystals as evidence of slow and gradual crystallisation, and I specially referred to zonal felspars which show a progressive change of species, from a more basic one at the heart of a crystal to a more acid one at its periphery. I explained this by referring to a law of general, though not of universal application, that the more basic minerals crystallised first, and that in a granite there is a progressive silicification of the magma as the basic minerals crystallise out, until at length nothing but free quartz remains. It is obvious that the gradual silicification of a plutonic rock must have been a process that extended over a considerable period of time, and in the case of a cooling granite there must have been a fall of temperature during this period. The crystallisation of a granitic mineral may therefore have begun at one temperature and have concluded at a much lower temperature. This is the more probable, as recent experiments on the melting-point of minerals appears to show that a period of plasticity precedes the development of rigidity in some minerals.

In the case of the beryl of the Satlej granite I certainly considered that its crystallisation had been a slow and gradual process. I showed that it was the first mineral to crystallise, and did so before the mica, the felspar, and the quartz had begun to form upon it. It seemed clear from the idiomorphic character of the beryl that the magma when it began to crystallise out was in a fluid condition, and I thought, as stated in my address, that a study of "thin slices of it under the microscope ought to give us a clue to the condition of the magma at the time the beryl was formed." The beryl contained, as I found by its microscopic study, not only inclusions of water, but inclusions of a gas. The evidence therefore seems to show that if the molecules of beryl entangled and brought down with them a gas or gases, there was no reason why they should not have brought down water in the gaseous state. That a molten magma at the heat supposed, rendered fluid by aqueo-igneous fusion, must have been in a perfectly mobile condition, permitting of the free motion of its constituents and an intermixture of its chemical elements, goes without saying.

The evidence submitted to the hearers of my address proves, I contend, that when the atoms of the chemical substances that constitute beryl came together to form molecules, and moved towards each other in the act of crystallisation, they entangled and brought down gases with them. There is nothing inherently improbable in this conclusion.

Those who have tried their hand at chemical analysis will understand how difficult it is to prevent a precipitate thrown down by chemical action from bringing down with it other substances which the chemist is anxious to retain in solution, repeated re-solution and re-precipitation being necessary in some cases where exact results are required. The power possessed by some metals at a high temperature of 'occluding' or absorbing hydrogen gas affords another highly suggestive illustration of molecular entanglement.

Thus Palladium, which possesses this power in a higher degree than any other metal, can absorb at a red-heat no less than 935 times its volume of hydrogen.[1] Doubtless hydrogen is not the only gas subject to occlusion. The discoveries in our own time regarding Helium, Argon, Uranium, and Radium have also shown us that chemical elements may long remain buried without their presence being suspected, as in the case of Argon, the presence of which in atmospheric air remained unsuspected until a few years ago.

The case of the gas Helium is also highly suggestive. The rare mineral Cleveite is the one with which Helium was at first associated, but astronomers[2] affirm that it is rather abundant in the sun and in many stars. The probability is, therefore, that it will hereafter be found in connection with other terrestrial minerals. The chemists of the future will no doubt discover buried in many rocks substances of which the ordinary chemical analysis has up to the present time taken little or no cognisance.

With these ideas running in my mind, I find no difficulty in believing that when beryl began to crystallise out of the magma of the Satlej granite its molecules should have entangled and brought down with them molecules of gas. The subsequent progress of the mineral seems to have been as follows:—The molecules came together above the critical temperature, bringing down entangled with them two or more gases. As cooling progressed and the temperature fell, the molecules of gas and the molecules of water in a gaseous state were enclosed in the mineral.

As the temperature still further fell the water passed from its gaseous condition to a fluid state, and as the rigidity of the beryl increased, the enclosures of water and gas were more and more compressed, until the dimensions of the cavities reached what we now see them to be. As the water thus shut up gradually lost its heat, the mineral matter, which had been held in solution by the heated water, was deposited. That this progressive development actually took place is, I think, proved by the evidence which shows that the beryl began to crystallise when the granite magma was still fluid, and that the beryl now contains inclusions of gas and of water with deposited minerals. That the granitic magma, when in a fluid condition, must have been above a red heat, is, I think, obvious.

When I visited Vesuvius in the Spring of 1885 I descended into the then existing crater, and approached its active centre as near as was safe. I then saw with my own eyes that the lava on which I stood was still red-hot immediately below its scoriaceous surface. If lava, after it has been poured out on the surface of the earth, still retains a red heat, we seem forced to the belief that an unconsolidated granitic magma buried at plutonic depths in the bowels of the earth must be in a still more heated condition.

Mr. Hunt, in his September paper, dwells at some length on volcanic conditions, and points to the case of Krakatoa as an illustration of sea-water having gained access to the roots of a volcano. But the case of an active volcano in the immediate vicinity of the sea is very different from that of a heated magma of a plutonic rock like granite, buried at great depths in the bowels of the earth, far removed from the sea.

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[1] Roscoe & Schorlemner's Treatise on Chemistry, new edition, 1894, p. 137.

[2] Miss Clerke's "Problems in Astrophysics," 1903.

The possibility of the access of sea-water to the root of a volcano like Krakatoa may be readily conceded, as this would explain in a reasonable way the tremendous explosion which took place, but Mr. Hunt, in his theory of the crystallisation of rocks, goes much further. He contends that the access of water would liquefy a rock that had consolidated and already cooled considerably at a dry heat (p. 403); and he argues on the same page that the pressure of water at 3,000 fathoms being 9,000 pounds to the square inch, water may have gained access through fissures to highly heated though consolidated rocks, and must have resulted in "liquefaction, reconstruction, recrystallisation, and metamorphosis in almost every variety."

If by these remarks Mr. Hunt contemplates the case of a granitic magma buried at plutonic depths, I doubt if he will find many geologists able to go with him, and still fewer to believe that if sea-water could gain access through open fissures to a granitic magma, it would lead to the quiet liquefaction and recrystallisation of the minerals of the granite.

In my Belfast address I said that Sorby had proved "that the liquid contained in the inclusions in granite is water, and showed that it was caught up during the formation of the crystals, and was not introduced subsequent to the consolidation of the rock." I think, if my critic wishes to convert geologists to his theories about the formation of granite, he should begin by showing that Sorby's facts are erroneous and that his verdict based upon them is unsound.

I have only time, in conclusion, to notice very briefly another adverse criticism by Mr. Hunt. He expresses his disbelief in the permeability of rocks, and adduces as counter evidence the case of inclusions of liquid carbon-dioxide. He has specimens, he tells us, which have been imprisoned since Devonian times, and although they are now contained in thin microscopic sections they have not escaped, though the pressure exerted by liquid carbon-dioxide is 1,155 pounds to the square inch.

When considering the question of the porosity and the permeability of rocks, one adverse case is not sufficient in my opinion to dispose of a good many instances which show that chemical reagents have, as a matter of fact, penetrated into rocks and minerals.

The permeability of one substance by a liquid or gas depends, among other things, on the relative size of the molecules of the invader, as compared with the size of the interspaces between the molecules of the crystal invaded. To take a homely simile, a sieve of small meshes will allow sand to readily pass through them, but will effectually bar the passage of half-crowns. Some crystals, therefore, may be permeable to certain chemical reagents, but not to others. I have heard on good authority that the permeability of agates is taken practical advantage of by German manufacturers in the preparation of agates for the market, beautiful internal dendritic markings, which add so much to their market value, being produced by soaking the agates in a succession of liquids. In my Belfast address, however, I did not consider the case of the permeability of cold crystals by cold solutions. On the contrary, my main object was to impress upon my hearers the fact "that heat increased the porosity of minerals, facilitated the passage of liquids laden with mineral matter through their pores, and increased the potency of chemical action."

In the course of my remarks I referred to numerous instances in which there was good evidence to show that crystals and rocks had been permeated by chemical reagents, and I need not go into these cases again. I do not see how the schillerisation of minerals or the formation of a pseudomorph of one mineral in the form of another can be accounted for if you do not believe in the permeability of heated rocks and crystals by heated chemical reagents. I foresaw that the idea of cracks and their subsequent obliteration would suggest itself to some minds, and in my Belfast address I said all that I considered necessary in reply to this suggestion.

V.—On a new Stegocephalian (*Batrachosuchus Browni*) from the Karroo Beds of Ariwal North, South Africa.

By R. Broom, M.D., B.Sc., C.M.Z.S.

In the collection of Mr. Alfred Brown, of Ariwal North, there is a fairly complete skull of a moderate-sized Stegocephalian which differs very considerably from that of any form hitherto described. The specimen is in a sandstone matrix. Owing to a crack produced by weathering practically all the cranial bones adhered to the counter slab when an endeavour was made to display the remains. The sculpturing of the bones is thus hidden, but the sutures are for the most part distinctly seen. Fig. 1 represents a slightly restored view of the upper side of the skull. The most striking features are the great breadth of the skull and the relatively advanced position of the orbits. In these respects it makes a slight approach to the condition found in the American genus *Diplocaulus*. There is no distinct notch in the post-temporal region, as in most Stegocephalians, and there are no 'epiotic' cornua. There are two rudimentary cornua on the posterior cranial border, but they are formed by the so-called 'supra-occipital' bones. In the middle line between the frontals and nasals is a median bone, probably an ethmoid. I fail to detect a supra-temporal element as distinct from the quadrato-jugal, which is of large size.

The under surface of the skull has only been partly cleared of matrix. The occipital region is well ossified and extends far backwards. The condyles are well developed. The most noteworthy feature of the palatal surface is the large size of the pterygoids. These, with the 'parasphenoid,' form more than a third of the under surface of the skull. The pterygoids also form two large descending plates, which lie close to the inner sides of the mandibles. The borders of the maxillaries and premaxillaries are unfortunately lost, but large teeth or the remains of them are seen, as indicated in Fig. 2. The position of the internal nares is also shown. The quadrate, which is apparently lost, has been small and possibly cartilaginous.

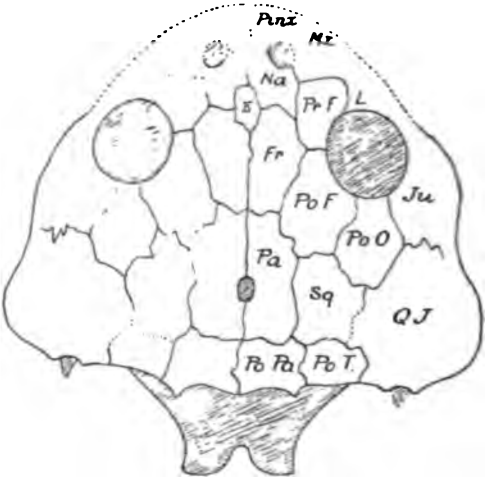

FIG 1.

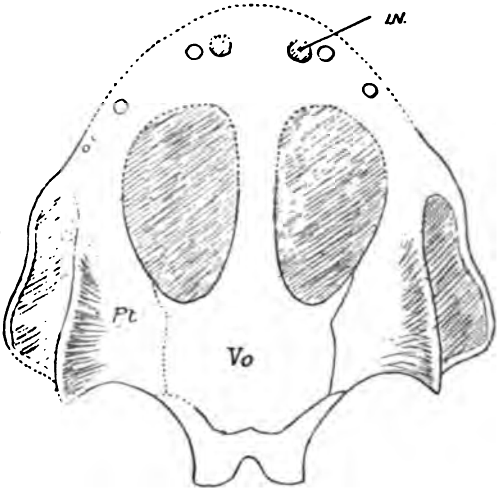

FIG. 2.

FIG. 1, UPPER, AND FIG. 2, LOWER VIEWS OF SKULL OF *Batrachosuchus Browni*, sp. nov. × ¼.

E. ethmoid; *Fr.* frontal; *I.N.* internal nares; *Ju.* jugal; *L.* lachrymal; *Mx.* maxilla; *Na.* nasal; *Pa.* parietal; *Pmx.* premaxilla; *Po.F.* postfrontal; *Po.O.* postorbital; *Po.Pa.* post-parietal (' supra-occipital ') ; *Po.T.* post-temporal (' epiotic') ; *Pr.F.* prefrontal ; *Pt.* pterygoid ; *Q.J.* quadrato-jugal ; *Sq.* squamosal; *Vo.* vomer (' parasphenoid ' of most authors).

In the absence of vertebræ it is impossible to be quite certain to which group of Stegocephalians the new form belongs. In the same beds, however, Mr. Brown has collected vertebral hypocentra of a size sufficiently large to have belonged to the form under consideration, and if, as is probable, the vertebral remains belong to the same form as the skull, its affinities will most probably be with those other forms which have rhachitomous vertebræ.

The extreme length of the skull from the occipital condyles has probably been about 250 mm. From the back of the ethmoid to the back of the 'supra-occipital' is 135 mm.; and the distance between the orbits 82 mm.

For the new form I propose the name *Batrachosuchus Browni*, in honour of the discoverer.

VI.—On a Preglacial or Early Glacial Raised Beach in County Cork.[1]

By H. B. Muff, B.A., F.G.S., and W. B. Wright, B.A.

[Communicated with the permission of the Director of the Geological Survey.]

THE existence of a raised beach formed, and probably elevated, before the deposition of the Boulder-clay has already been demonstrated in South Wales[2] and Yorkshire.[3] During the progress of the Drift Survey of the country surrounding Queenstown Harbour, a beach of similar age was observed along the shores of the harbour, and was subsequently traced at intervals along the adjoining coast of Waterford and Cork from Dungarvon to Clonakilty, a distance from east to west of about sixty miles.

The relation of this beach to the well-known submerged river valleys of the south of Ireland is a point of considerable interest. The finding of glacial drift and striæ within the valleys led at once to the recognition of their preglacial excavation, but the subsequent tracing of the raised beach beneath the Boulder-clay along their banks showed that their submergence was also preglacial.

The most persistent relic of the raised beach is a water-worn rock platform, of varying width, sloping gently seaward and terminated at its landward side by a rocky cliff against which the deposits overlying the beach are banked. The higher portions of this platform, just at the foot of the cliff, are from five to ten feet above high-water mark—that is, perhaps, seven to twelve feet above the higher portions of the corresponding plane of erosion in process of formation at the present day.

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[1] This paper was read in abstract before the British Association, Southport, September, 1903, in Section C (Geology).

[2] R. H. Tiddeman, "On the Age of the Raised Beach of Southern Britain as seen in Gower": Rep. Brit. Assoc., 1900, p. 760. See also Summary of Progress of the Geological Survey of the United Kingdom for 1899, pp. 154, 155.

[3] G. W. Lamplugh, "Report of the Committee appointed for the Purpose of investigating an Ancient Sea-beach near Bridlington Quay": Rep. Brit. Assoc., 1890, p. 375. See also Proc. Yorkshire Geol. and Polytechnic Society, 1887, p. 381; and "The Drifts of Flamborough Head," Quart. Journ. Geol. Soc., vol. xlvii, p. 384.

The overlying deposits, where completely developed, exhibit the following succession of strata:—

5. Upper 'head.'
4. Boulder-clay.
3. Lower 'head.'
2. Blown sand.
1. Raised-beach shingle and blocks from cliff.
Rock platform.

The 'head' is composed of angular fragments of rocks similar in character to those forming the cliffs above. It has a bedded appearance, like that of a tip-heap, but there is no sorting of material. By far the greater proportion of it lies below the Boulder-clay. The upper 'head' often contains rounded stones derived from the drift.

The Boulder-clay contains well-scratched subangular stones, all local, but much more miscellaneous than those in the 'head.'

The blown sand is found banked against the cliff behind the 'head,' which has the appearance of having slipped down little by little over it. The rock cliff often has a polished appearance, probably due to the action of the wind-borne sand.

The shingle lies upon the platform among the blocks, which have evidently fallen from the cliff above. The blown sand is heaped over and among these blocks, which are absent in sections further from the old cliff. The shingle in these seaward sections is often replaced by fine stratified beach-sand.

As the present coastline recedes from the old cliff, the 'head,' both upper and lower, is seen to thin out and finally disappear. The Boulder-clay, on the other hand, thickens at first to seaward, until it replaces the 'head' and comes to lie directly on the rock platform, which is often beautifully glaciated beneath it. When sufficiently preserved, however, it can be seen to thin out further seaward, having in section a somewhat lenticular shape.

The sections are, of course, not always as complete as indicated above. Sometimes one member is absent, sometimes another, but the succession is invariable. With the exception of a few fragmentary shells no fossils have up to the present been found in any of the deposits.

The superposition of the Boulder-clay and the glaciation of the rock platform are taken to prove the preglacial—or, more strictly, the pre-Boulder-clay—age of the beach.

The occurrence of blown sand and lower 'head' indicates an elevation of the beach prior to the deposition of the Boulder-clay.

The preponderance of the lower over the upper 'head' is no doubt due to the greater steepness in preglacial times of the dominating cliff or slope from which the 'head' was derived. It is as a consequence not to be taken as any indication of a longer lapse of time between the elevation of the beach and the period of glaciation, than between that period and the present day. On the contrary, the occurrence of flints in the beach near Clonakilty points to the presence of floating ice during its formation, and indicates a beginning of glacial conditions even before the commencement of the elevation.

In Ballycroneen Bay a section of more than usual interest is exposed. The 'head,' which here rests immediately on the rock-ledge, is overlain by two distinct Boulder-clays. The lower of these contains shell-fragments, chalk flints, and boulders of Wexford and Waterford rocks, and is obviously the Boulder-clay of the Irish Sea ice. The upper is the ordinary local Boulder-clay of the district laid down by the ice which moved from west to east over Cork. The beach is therefore prior to both these ice-flows.

The postglacial raised beach is also represented in Cork Harbour, and is quite distinct from the preglacial beach. It consists for the most part of ledges of estuarine clay lying in sheltered spots and raised two feet or so above high-water mark.

The relative succession of events for which evidence has been obtained appears to have been as follows:—

1. Land higher than at present — erosion of valleys now submerged.
2. Land depressed to about eight or ten feet below present level—formation of preglacial raised beach.
3. Elevation of land—accumulation of blown sand, and subsequently of lower 'head.'
4. Advance of the Irish Sea ice from the east at least as far as Power Head, and deposition of marly Boulder-clay, followed by advance of ice from west Cork and deposition of upper 'local' Boulder-clay.
5. Accumulation of upper 'head'—land at some time about three feet lower than at present, deposition of estuarine clays now above high-water mark.

Finally, we would call attention to the complete similarity of the preglacial beach to that of Gower in South Wales, described by Mr. Tiddeman. The only difference worthy of notice is the comparative scarcity of fossils in the Cork beach—a difference which is easily accounted for by the quantity of spring water which issues along the platform through the gravel and sand of the beach.

VII.—A RAPID AND EASY METHOD OF ESTIMATING SPECIFIC GRAVITIES.

By WILLIAM MACKIE, M.A., M.D.

THE following rapid and for most purposes sufficiently accurate method of estimating specific gravities of rocks, minerals, sands, etc., will recommend itself to those familiar with the apparatus of the chemical laboratory.

The substance, if a rock or mineral, is first broken into coarse fragments under ¼ inch in diameter. A quantity of the fragments is then accurately weighed in a porcelain crucible or other handy vessel. Say this weight is *W*. An ordinary burette graduated in $\frac{1}{10}$ c.c. is filled with water to a certain height, say, *X* c.c. (which is noted). The fragments in the crucible are then taken one by one and carefully placed in the burette, care being taken at the same time that nothing is lost in the transference. The finer débris may be left in the crucible. During the transference the burette may be smartly tapped from time to time to detach air bubbles from the fragments. The crucible is again weighed—say the weight is now W'. The height of the water in the burette is now taken. Say it is X' c.c. When we have $W-W'$ = weight of substance taken, $X-X'$ = number of c.c. occupied by quantity of substance taken, whence $\frac{W-W'}{X-X'}$ = specific gravity required.

I append the first ten determinations which were made by this method. Some of them were checked by other methods. From these the general accuracy of the method will readily be inferred.

Rocks, Minerals, Sands, etc.	Quantity taken. Grams.	No. of c.c. displaced.	Calculated Specific Gravity.
Granite	10·822	4·1	2·64
Porphyritic Olivine Basalt	8·483	2·9	2·925
Fine Sandstone	11·47	4·4	2·6
Sandstone cemented with $BaO\,SO_4$ [1]	14·062	4·4	3·2 nearly
,, ,, ,, CaF_2 [1]	13·447	4·85	2·77
Calcite	10·17	3·7	2·75 nearly
Basic Rock (altered)	13·452	4·9	2·74
Garnet and Iron Sand	14·88	3·8	3·92 }
Same by Sp.g. bottle	6·813	—	3·936 }
Shot in large pellets	79·328	7·1	11·17 }
(again)	103·754	9·3	11·16 }
Epidiorite	13·953	4·9	2·85 }
By Sp.g. bottle	4·84	—	2·84 }

NOTICES OF MEMOIRS, ETC.

I.—Floras of the Past: their Composition and Distribution.[2]

By A. C. Seward, F.R.S., Fellow and Tutor of Emmanuel College, Lecturer on Botany in the University of Cambridge.

AFTER speaking of the important work accomplished by Professor Williamson, of Manchester, as a palæobotanist, and referring to his methods of microscopic investigation of the Carboniferous plants, Professor Seward said:—My aim is to put before you in this address one aspect of palæobotany which has not received its due share of attention: I mean the geographical distribution of the floras of the past. I recognise the futility of expecting conclusions of fundamental importance from such an incomplete examination of the available evidence as I have been able to undertake; but a hasty sketch may serve to indicate the impressions likely to be conveyed by a more elaborate picture.

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[1] Brit. Assoc. Rep. 1901, p. 649.

[2] Being the Presidential Address to the Botanical Section of the British Association for the Advancement of Science, Southport, September, 1903.

In endeavouring to take a comprehensive survey of the records of plant-life, we should aim at a wider view of the limits of species, and look for evidence of close relationship rather than for slight differences, which might justify the adoption of a distinctive name. Our object, in short, is not only to reduce to a common language the diverse designations founded on personal idiosyncrasies, but to group closely allied forms under one central type. We must boldly class together plants that we believe to be nearly allied, and resist the undue influence of considerations based on supposed specific distinctions.

As a preliminary consideration, we must decide upon the most convenient means of expressing the facts of geographical distribution in a concise form. The recognised botanical regions of the world do not serve our purpose; we are not concerned with the present position of mountain-chains or wide-stretching plains that constitute natural boundaries between one existing flora and another, but simply with the relative geographical position of localities from which records of ancient floras have been obtained. I have divided the surface of the earth into six belts, from west to east. The most northerly or *Arctic Belt* includes the existing land-areas as far south as latitude 60°, comprising—1, Northern Canada; 2, Greenland and Iceland; 3, Northern Europe; 4, Bear Island and Spitzbergen; 5, Franz Josef's Land; 6, Northern Asia. The *North Temperate Belt,* extending from latitude 60° to 40°, includes—7, South Canada and the northern United States; 8, Central and Southern Europe; 9, Central Asia. The *North Subtropical Belt* comprises the land between latitude 40° and the Tropic of Cancer, including—10, the Southern States of North America; 11, Northern Africa, part of Arabia and Persia; 12, Thibet, and part of China; 13, Japan. The *Tropical Belt,* embracing the land-areas between the Tropics of Cancer and Capricorn, includes—14, Central America and the northern part of South America; 15, Central Africa and Madagascar; 16, India, the Malay Archipelago, and Northern Australia. The *South Subtropical Belt,* extending from the Tropic of Capricorn to latitude 40° South, includes—17, Central South America; 18, South Africa; 19, Central and Southern Australia. The *South Temperate Belt* includes—20, the extreme south of South America; 21, Tasmania; 22, New Zealand.

PRE-DEVONIAN FLORAS.—The scanty records from pre-Devonian rocks afford but little information as to the nature of the vegetation that existed during the period in which were deposited the Cambrian, Ordovician, and Silurian strata that now form the greater portion of the Welsh and Cumberland hills.

The genus *Nematophycus,* originally described by Dawson as *Prototaxites,* and afterwards referred by Carruthers to the Algæ, constitutes the most satisfactory example of a Silurian plant. This genus, which has fortunately been preserved in such a manner as to admit of minute microscopical examination, represents a widely spread algal type in Silurian and Devonian seas. The tubular elements composing the stems of some species of *Nematophycus*—

which reached a diameter of 2 or 3 feet—exhibit a regular variation in width, giving the appearance of concentric rings of growth, as in the stems of the tree-like *Lessonia*, an existing genus of Antarctic seaweeds. This structural feature presents an impressive image in stone of a plant's rhythmical response to some periodically recurring conditions of growth in the waters of Palæozoic seas.

DEVONIAN AND LOWER CARBONIFEROUS FLORAS.—The earliest plants that have been found in sufficient number, and in a state of preservation which renders their identification possible, are those from Devonian rocks.

What do we know as to the composition of the floras that flourished in the later stages of the Devonian and in the lower part of the Carboniferous era? The following list, which is by no means exhaustive, represents some of the more important generic types which may be very briefly described:—

1. EQUISETALES.
    Archæocalamites.
2. SPHENOPHYLLALES.
    Sphenophyllum.
    Cheirostrobus.
    [*Pseudobornia* ?]
3. LYCOPODIALES.
    Lepidodendron.
    Bothrodendron.
4. FILICALES.
    Archæopteris.
    Adiantites.
    Rhodea.
    Cardiopteris.
    Todeopsis.
    Cephalotheca.
    Rhacopteris.
5. CYCADOFILICES.
    Calamopitys.
    Heterangium.
    Lyginodendron.
6. GYMNOSPERMÆ.
    (CORDAITALES.)
    Cordaites.
    Pitys.

In *Archæocalamites* we have the oldest example of an undoubted Equisetaceous genus. The structure of its comparatively thick and woody stem is practically identical with that of our common British type of *Calamites*, one of the most abundant of the Coal-period genera, while the strobilus differed in no essential feature from that of a modern Horsetail. The genus *Cheirostrobus*, founded in 1897 by Dr. D. H. Scott on a single specimen of a petrified cone, affords a striking illustration of a Palæozoic plant exhibiting a structure far more complex than that of any known type among existing Vascular Cryptogams. In this Scotch cone, about 3·5 cm. in diameter, we recognise Equisetaceous and Lycopodinous characters combined with morphological features typical of the extinct genus *Sphenophyllum*. Both Devonian and Culm rocks have furnished many examples of Lycopodinous plants. The genus *Bothrodendron*, closely allied in habit to *Lepidodendron*, has been recorded from Bear Island, Ireland, and Australia, and the cuticles of a Lower Carboniferous species form the greater portion of the so-called paper-coal of Tula in Russia. *Lepidodendron* itself had already attained to the size of a forest tree, with anatomical features precisely similar to those of the succeeding Coal-period species.

Our knowledge of the ferns is not very extensive. The genus *Archæopteris* from Ireland, Belgium, Bear Island, and North America has always been regarded as a fern, but we must admit the impossibility of accurately determining its systematic position until we possess a fuller knowledge of the reproductive organs and of its anatomical structure. Similarly, the genera *Rhacopteris*, *Adiantites*, and *Rhodea* may be provisionally retained among the oldest known ferns. The genus *Cardiopteris* — a plant with large oblong or orbicular pinnules borne in two rows on a stout rachis—is known only in a sterile condition, and it is quite as likely that its reproductive organs may have been of the Gymnospermous as of the Filicinean type.

The petrified remains of stems and leaves of such plants as *Heterangium*, *Lyginodendron*, *Calamopitys*, and others which demonstrate the existence of a class of synthetic genera combining Filicinean and Cycadean characters, are of exceptional interest as showing beyond doubt that Ferns and Cycads trace their descent from a common ancestry. The announcement made a few months ago by Professor Oliver and Dr. Scott that they had obtained good evidence as to the connection of the gymnospermous seed known as *Lagenostoma* with the genus *Lyginodendron* is one of the most important contributions to botany published in recent years; if, as I firmly believe, the evidence adduced is convincing, it gives satisfactory confirmation to suspicions that previous discoveries led us to entertain. The fact demonstrated is this: the genus *Lyginodendron*, a plant known to have existed during the greater part of the Carboniferous epoch, possessed a stem of which the primary structure was almost identical with that which characterises some recent species of Osmundaceæ, while the secondary wood produced by the activity of a cambium is hardly distinguishable from the corresponding tissue in the stem of a recent cycad. The fronds were those of a fern, both in the anatomy of their vascular tissue and in their external form; as far, therefore, as the vegetative characters are concerned, we have a combination of ferns and cycads. We still lack complete knowledge of the nature of the reproductive organs, but it seems clear that *Lyginodendron* bore seeds constructed on the Gymnospermous plan, but characterised by an architectural complexity far beyond that represented in the seeds of any modern Conifer or Cycad.

In such genera of Gymnosperms as *Cordaites*, *Pitys*, and others, we have examples of forest trees possessing wood almost identical with that of existing species of *Araucaria*, but distinguished by certain peculiarities which point to a relationship with members of the Cycadofilices, and suggest that Conifers as well as Cycads may have sprung from a filicinean stock.

Two facts stand out prominently as the result of a general survey of what are practically the oldest records of plant-life. One is the abundance of types which cannot be accommodated in our existing classification, founded solely on living plants.

The Devonian and Lower Carboniferous plants lead us away from the present along converging lines of evolution to a remote stage in the history of life; they bring us face to face with proofs of common origins, which enable us to recognise community of descent in existing groups between which a direct alliance is either dimly suggested or absolutely unsuspected if we confine our investigations to modern forms.

Another fact that seems to stand out clearly is the almost world-wide distribution of several characteristic Lower Carboniferous plants. We are, as yet, unable to follow these Devonian plants to an earlier stage in their evolution. We are left in amazement at their specialised structure and extended geographical distribution, without the means of perusing the opening chapters of their history.

UPPER CARBONIFEROUS (COAL-MEASURES) AND PERMIAN FLORAS.—The vast forests of the Coal age occupied an extensive area of land on the site of the present United States of North America, stretching across Europe into Eastern Asia; under the shade of their trees lived "the stupid, salamander-like Labyrinthodonts, which pottered with much belly and little leg, like Falstaff in his old age." The plants of these Palæozoic forests seem to be revivified, as we subject their petrified fragments to microscopical examination. Robert Louis Stevenson has referred to a venerable oak which has been growing since the Reformation and is yet a living thing, liable to sickness and death, as a speaking lesson in history. How much more impressive is the conception of age suggested by the contemplation of a group of Palæozoic tree-stumps exposed in a Carboniferous quarry and rooted where they grew! An examination of their minute anatomy carries us beyond the mere knowledge of the internal architecture of their stems, leaves, and seeds; it brings us into contact with the actual working of their complex machinery. As we look at the stomata on the lamina of a leaf of one of those strange trees, and recognise a type of structure in the mesophyll-tissues which has been rendered familiar by its occurrence in modern leaves, it requires but little imagination to see the green blade spreading its surface to the light to obtain a supply of solar energy with which to extract carbon from the air. We can almost hear the murmur of plant-life and the sighing of the branches in the wind as the sap courses through the wood, and the leaves build up material from the products of earth and air; products that are to be sealed up by subsequent geological changes, till after the lapse of countless ages the store of energy accumulated in coal is dissipated through the agency of man.

Time does not admit of more than the most cursory glance at the leading types of the Permo-Carboniferous floras. The general character of the preceding vegetation is retained with numerous additions. *Archæocalamites* is replaced by a host of representatives of the genus *Calamites*, an Equisetaceous type with stout woody stems and several forms of cones of greater complexity than those of modern Horsetails. Side by side with the Calamites there appear to have existed plants which, from their still closer agreement with *Equisetum*, have been described by Zeiller, Kidston, and others as species of *Equisetites*. The genus *Sphenophyllum*, a solitary type of an extinct family, was represented by several forms which, like the *Galium* of our hedgerows, may have supported their slender branches against the stems of stronger plants. Lycopods, with trunks as thick and tall as forest trees, were among the most vigorous members of the later Palæozoic forests. Although recent research has shown that several of the supposed ferns must be assigned to the Cycad-fern alliance, there can be no doubt that true ferns had reached an advanced state of evolution during the Permo-Carboniferous epoch. The abundance of petrified stems of the genus *Psaronius*, of which the nearest living representatives are probably to be found among the tropical Marattiaceæ, demonstrates the existence of true ferns. The most striking fact as regards the Permo-Carboniferous ferns is the abundance of fertile fronds bearing sporangia which exhibit a more or less close agreement with those of the few surviving genera of Marattiaceæ. The more familiar type of sporangium met with in our existing fern-vegetation is also represented, and we have recently become familiar with several genera bearing sporangia exhibiting a close resemblance to those of modern Gleicheniaceæ, Schizæaceæ, and Osmundaceæ. The sporangial characteristics of the different families of living ferns are many of them to be found among Palæozoic types, but there is a frequent commingling of structural features showing that the ferns had not as yet become differentiated into so many or such distinct families as have since been evolved.

Prominent among the Gymnosperms of the Palæozoic forests must have been the genus *Cordaites*: tall handsome trees, with long strap-shaped leaves. This genus, which has been made the type of a distinct group of Gymnosperms, combined the anatomy of an *Araucaria* with reproductive organs more nearly allied to the flowers of Cycads, and exhibiting points of resemblance with those of the Maidenhair-tree. It is not until the later stages of the Permo-Carboniferous epoch that more definite coniferous types made their appearance. The Maidenhair-tree of the Far East, one of the most venerable survivors in our modern vegetation, is foreshadowed in certain features exhibited by *Cordaites* and, as regards the form of its leaves, by *Psygmophyllum*, *Whittleseya*, and other genera. Leaves have been found in Permian rocks of Russia, Siberia, Western and Central Europe, referred to the genus *Baiera*, a typical Mesozoic type closely allied to *Ginkgo*. In the Upper Coal-measures and Lower Permian rocks a few pinnate fronds have been discovered, which bear a striking likeness to modern Cycadean leaves. Throughout the Permo-Carboniferous era the Cycadofilices formed a dominant group; *Lyginodendron*, *Medullosa*, *Poroxylon*, and many other genera flourished in abundance as vigorous members of an ancient class which belongs exclusively to the past.

One distinctive characteristic of the vegetation of later Permo-Carboniferous days is the occurrence of the Cycad-like fronds already referred to; also the appearance of *Voltzia* and other conifers with species of *Equisetites*, pioneer genera of a succeeding era that constitute connecting links between the Palæozoic and Mesozoic floras.

What we may call the typical vegetation of the Coal-measures, which continued, with comparatively minor changes, into the succeeding era, flourished over a wide area in the northern hemisphere, suggesting, as White points out, an almost incredible uniformity of climate. We have already noticed the existence in the southern hemisphere of Lower Carboniferous and Devonian genera identical with plants found in rocks of corresponding age within the Arctic circle. This agreement between the northern and southern floras was, however, not maintained in the later stages of the Palæozoic epoch. Australian plant-bearing strata, homotaxial with Permo-Carboniferous rocks of Europe, have so far afforded no examples of *Sigillaria*, *Lepidodendron*, or of several other characteristic northern forms; in place of these genera we find an enormous abundance of a fern known as *Glossopteris*. With *Glossopteris* was associated a fern bearing similar leaves, known as *Gangamopteris*, and with these grew *Schizoneura* and *Phyllotheca*, members of the Equisetales. In addition to these genera there are others which bear a close resemblance to northern hemisphere types, such as *Noeggerathiopsis*, a member of the Cordaitales, and several species of *Sphenopteris*. Similarly, in many parts of India, *Glossopteris* has been found in extraordinary abundance in the same company with which it occurs in Australia. In South Africa an identical flora is met with which extends to the Argentine and to other regions of South America. It is clear that from South America, through South Africa and India to Australia, there existed a vegetation of uniform character which flourished over a vast southern continent at approximately the same period as that which, in the northern hemisphere and in China, witnessed the growth of the forests whose trees formed the source of our coal-supply.

Since attention was drawn by Dr. Blanford and other writers to the facts of plant-distribution revealed by a study of the later Palæozoic floras, it has been generally admitted that during the Permo-Carboniferous era there existed two fairly well-marked botanical provinces. The more familiar and far richer flora occupied a province stretching from the western states of North America across Europe into China and reaching as far as the Zambesi; the other province was occupied by a less varied assemblage of plants, characterised by the abundance of *Glossopteris*, *Gangamopteris*, *Neuropteridium*, *Noeggerathiopsis*, *Schizoneura*, and other genera, stretching from South America through India to Australia.

In Brazil, Professor Zeiller has recorded the occurrence of a flora including *Lepidophloios*, a well-known European member of the Lycopods, associated with such characteristic southern types as *Gangamopteris* and *Noeggerathiopsis*. Similarly, from the Transvaal a European species of *Sigillaria*, with a Lepidodendroid plant, and another northern genus, *Psygmophyllum*, have been found in beds containing *Glossopteris*, *Gangamopteris*, *Noeggerathiopsis*, *Neuropteridium*, and other members of the so-called Glossopteris flora. In India, the Glossopteris flora exhibits an entire absence of *Lepidodendron*, *Calamites*, *Sigillaria*, and other common northern genera, while *Sphenophyllum* is represented by a single species. The Australian Permo-Carboniferous flora is also characterised by the absence of the great majority of the northern types. Until a few years ago the genus *Glossopteris* had not been discovered in Europe, but in 1897 Professor Amalitzky recorded the occurrence of this genus in association with *Gangamopteris* in Permian strata in northern Russia.

We see, then, that in Brazil and South Africa the Glossopteris flora and the northern flora overlapped, but the former was the dominant partner. On the other hand, in rocks belonging to a somewhat higher horizon in Russia, we meet with a northern extension of the Glossopteris flora.

There seems good reason for assuming that the Glossopteris flora originated in the South, and before the close of the Permian period, as well as in the succeeding Triassic era, pushed northward over a portion of the area previously occupied by the northern flora. This northward extension is shown by the existence of *Glossopteris* in Upper Permian rocks of Russia, by the occurrence of several southern types in plant-bearing beds of the Altai Mountains, and by the existence in Western Europe during the early stages of the Triassic era of such southern genera as *Neuropteridium* and *Schizoneura.*

TRIASSIC, JURASSIC, AND WEALDEN FLORAS.—It is unfortunate that the records of plant-life towards the close of the Palæozoic and during the succeeding Triassic period are very fragmentary; the documents are few in number, and instead of the fairly continuous chapters in which the records of the Coal age have been preserved, we have to be content with a few blurred pages. During the Triassic period the vegetation of the world gradually changed its character; the balance of power was shifted from the Vascular Cryptogams, the dominant group of the Palæozoic era, to the Gymnosperms.

One of the few floras of early Triassic age of which satisfactory relics have been preserved is that described in 1844 by Schimper and Mougeot from the Bunter Sandstones of the Vosges. The genus *Neuropteridium,* a plant which may be a true fern, or possibly a surviving member of the Cycadofilices, is represented by a species which can hardly be distinguished from that which flourished in South America, South Africa, and India in the Permo-Carboniferous period. This genus and another southern type, *Schizoneura,* both of which are met with in the Triassic rocks of the Vosges, would seem to point to a northern migration of certain members of the *Glossopteris* flora, which took place at the close of the Palæozoic era. In the Lower Triassic flora Conifers are relatively more abundant than in the earlier periods; such genera as *Albertia* (resembling in its vegetative features some recent species of *Araucaria*), *Voltzia* (with cones that cannot be closely matched with those of any existing members of the Coniferæ), and other representatives of this class are common fossils. *Lepidodendra* have apparently ceased to exist; *Sigillaria* may be said to survive in one somewhat doubtful form, *Sigillaria oculina.* The genus *Pleuromeia,* which makes its appearance in Triassic rocks, is perhaps more akin to *Isoetes* than to any other existing plant. The Calamites are now replaced by large

Equisetaceous plants, which are best described as Horsetails with much thicker stems than those of their modern descendants.

Passing to the Peninsula of India, we find the genus *Glossopteris* abundantly represented in strata which there is good reason for regarding as homotaxial with the European Trias, and the occurrence in the same beds of some other genera of Permo-Carboniferous age shows that the change in the character of the southern vegetation at the close of the Palæozoic era was much more gradual than in the north.

The comparative abundance of plant remains in the northern hemisphere in rocks belonging to the Rhætic formation is in welcome contrast to the paucity of the records from the underlying Triassic strata. From Virginia and adjacent districts in the United States a rich flora has been described, which by some authors is assigned to the Keuper or Upper Triassic series, while others class it as Rhætic. A similar assemblage of plants is known also from the Lettenkohle beds of Austria, which, as Stur has shown, clearly belong to the same period of vegetation as the American flora.

(*To be continued.*)

II.—ON SOME DINOSAURIAN BONES FROM SOUTH BRAZIL. By A. SMITH WOODWARD, LL.D., F.R.S.

THE author had received from Professor H. von Jhering a few cervical vertebræ and phalangeal bones of a reptile discovered by Dr. Fischer in red rocks in the province of Rio Grande do Sul, Brazil. He described these remains, and suggested that they belonged to a short-necked Dinosaur. The ungual phalanges were especially remarkable, apparently unique, in being deeply concave on their inferior face and having a very sharp rim. Comparison seemed to show that, among known Dinosaurs, the cervical vertebræ most closely resembled those of *Euskelesaurus* from the Karoo formation of South Africa. The newly-discovered bones were therefore probably the first traces of the Gondwana-land terrestrial fauna, the discovery of which had long been expected in South America.

III.—ON A CARBONIFEROUS ACANTHODIAN FISH, *GYRACANTHIDES*. By A. SMITH WOODWARD, LL.D., F.R.S.[1]

THE author exhibited and described a restored drawing of *Gyracanthides* from the Carboniferous of Victoria, Australia. The fossil had pectoral fin-spines much like those named *Gyracanthus* from the Carboniferous of the northern hemisphere, but these spines lacked posterior denticles. The fish was either toothless or with minute teeth which had escaped observation. It was covered with dense shagreen, but there were no enlarged plates round the eyes. The body was depressed and broad in front, with a small and not very stout tail. The pectoral fins were relatively large, with almost sickle-shaped spines, while the pelvic fins were rather small, with straighter spines, and situated very far forwards. There were two pairs of peculiar free spines near the base of the pectoral fins. The two dorsal fins and the anal fin were provided with much smaller spines. *Gyracanthides* was evidently one of the most highly specialised Acanthodians, and showed that among these primitive fishes, as among modern Teleosteans, there was a tendency for the pelvic pair of fins to become displaced forwards in the higher types. The author had already described the same phenomenon in the typical family Acanthodidæ.

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[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

IV.—Land-Shells in the Infra-Glacial Chalk-rubble at Sewerby, near Bridlington.[1] By G. W. Lamplugh, F.G.S.[2]

THE Chalk-rubble which underlies the glacial drifts of Flamborough Head has not hitherto been known to contain organic remains. In a recent exposure of this material on the foreshore between Bridlington Quay and Sewerby the writer found numerous small fragile land-shells contained principally in intercalated streaks of brown earth. These shells belong mainly, if not entirely, to the species *Pupa muscorum*, Linn. The level at which they were found was about 8 feet below the top of the Sewerby Infra-Glacial sea-beach, and the Chalk-rubble is known to descend to at least 25 feet below this level.

The rubble usually rests directly upon the Chalk, but at Sewerby it overlies the Infra-Glacial blown-sand which is banked against the buried cliff of chalk. The presence of the land-shells proves that the rubble is a subaërial rainwash, and that it was formed when the sea stood at a lower level than when the Infra-Glacial beach was deposited. The conditions thus indicated are strikingly similar to those which obtain in the deposits associated with the Infra-Glacial buried shores of South Wales and co. Cork, where the old marine beaches and the accompanying blown-sand are covered by local rainwash or 'head.' and then by Boulder-clay.

The Chalk-rubble at Sewerby contains many small pieces of flint, though no flint is present in the Chalk within two miles of this locality; a few small fragments of yellow grit or quartzite foreign to the neighbourhood, along with one subangular boulder of similar rock 18 inches in diameter, were also found in it. Part of the material was probably deposited almost immediately before the glaciation of the district.

V.—On Dedolomitisation. By J. J. H. Teall, M.A., F.R.S., Director of the Geological Survey.[2]

THE Durness dolomites, as they approach the plutonic complex of Cnoc-na-Sroine, become transformed into a white marble which generally contains one or more of the following minerals: forsterite, or serpentine after forsterite, tremolite, diopside, and brucite. The dominant carbonate of the marble is calcite, but dolomite occurs in variable quantity. The amount of dolomite decreases as the total amount of the magnesian silicates and brucite increases. The original dolomite contains a variable amount of silica in the form of chert.

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[1] The full text of this paper will be published in *Proc. Yorks. Geol. and Polytech. Society.*

[2] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

When the altered rocks are examined under the microscope it is seen that forsterite, serpentine, and tremolite are invariably associated with calcite, but that diopside is sometimes associated with dolomite. These facts of paragenesis can be easily accounted for if we assume that the silica of the original dolomitic rock has combined with the bases of the carbonate, and preferably with the magnesia, for diopside is rare. Thus forsterite, a magnesian silicate, cannot have been formed in the dolomite without the liberation of lime, and consequently we find either detached crystals of forsterite surrounded by aureoles of calcite in a matrix of dolomite, or, when forsterite is abundant, a simple aggregate of forsterite and calcite. The formation of tremolite in which the ratio of $CaO : MgO$ is 1 : 3 also implies the separation of lime from magnesia; and it is invariably found, like the forsterite, in direct contact with calcite. But in diopside the ratio of $CaO : MgO$ is the same as in dolomite; so that in accordance with the principles above explained we should expect to find these two minerals in contact, and this has been observed.

The above facts clearly point to the conclusion that the cherty dolomites have been dedolomitised by the formation of magnesian silicates. Carbonic acid has been driven off, but the ratio of the bases has not been disturbed. The ratio of $CaO : MgO$ in the altered as in the unaltered rocks is approximately 1 : 1.

But dedolomitisation has also been produced in another way. Certain varieties of the marble are composed of calcite and brucite. The brucite is probably a pseudomorph after periclase, just as the serpentine is a pseudomorph after forsterite. We are therefore compelled to conclude that, under the conditions which prevailed during the intrusion of the plutonic rocks, the carbonic acid freed itself more readily from the magnesia than from the lime; thus, in the absence of silica, giving rise to the formation of periclase and converting the original dolomite into an aggregate calcite and periclase, the latter mineral subsequently being changed to brucite. The resulting rock is identical with the well-known predazzite of the Tyrol, which was probably formed in a similar way.

VI.—On the Fossil Flora of the Ardwick Series of Manchester.

By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

The Ardwick Series of Manchester forms the highest portion of the Coal-measures of the great South Lancashire Coalfield. The plant-remains in the shales associated with the *Spirorbis* Limestones of this series have been already mentioned or described by Williamson, Salter, and especially by the late E. W. Binney.

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[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

A revision of these records has been recently undertaken with a view to determining the true position of the Ardwick Series in the Coal-measures as indicated by the character of the flora. For this purpose Binney's collection, now in the Sedgwick Museum, Cambridge, has been re-examined, and several further identifications have been made. The flora is found to belong to a palæobotanical horizon known as the Upper Transition Series, which is antecedent to the true Upper Coal-measures, and which is represented in several English and Welsh Coalfields. The Lower Pennant Grits in the South Wales and the New Rock and Vobster Series in the Somersetshire Coalfields belong to this horizon.

VII.—Fossil Floras of South Africa. By A. C. Seward, F.R.S.[1]

1. *Uitenhage Flora.*—The plants from the Uitenhage series of Cape Colony include types characteristic of Wealden and others more closely allied to Jurassic species. On the whole there is a balance of evidence in favour of a Wealden horizon.

Onychiopsis Mantelli (Brongn.).
Cladophlebis Browniana (Dunk.).
Cladophlebis denticulata (Brongn.), forma *Atherstonei*.
Sphenopteris Fittoni (Sew.).
Sphenopteris, sp.
Tæniopteris, sp.
Zamites recta (Tate).
Zamites Morrisii (Tate).
Zamites africana (Tate).
Zamites Rubidgei (Tate).
Nilssonia Tatei, sp. nov.
Cycadolepis Jenkinsiana (Tate).
Benstedtia, sp. (cf. *Coniferocaulon Columbeæforme*, Fliche).
Carpolithes, sp.
Araucarites Rogersi, sp. nov.
Taxites, sp.
Brachyphyllum, sp.
Conites, sp. *a.*
Conites, sp. *β.*
Coniferous wood.
Planta incertæ sedis.

2. *Stormberg Flora.*—The plants from the Stormberg series point to a flora of Rhætic age. The Rhætic vegetation, of which remnants have been recorded from Scania, Franconia, and other parts of Germany, North America, New Mexico, Honduras, Tonkin, China, Turkestan, India, Australia, South America, and elsewhere, was characterised by its uniform character throughout the world.

Schizoneura Krasseri, sp. nov.
Strobolites, sp.
Thinnfeldia odontopteroides (Morr.).
Thinnfeldia rhomboidalis (Ett.).
Cladophlebis, sp. (Feistmantel).
Callipteridium stormbergense, sp. nov.
Tæniopteris Carruthersi (Ten.-Woods).
Chiropteris cuneata (Carr.).
Chiropteris Zeilleri, sp. nov.
Baiera stormbergensis.
Baiera Schencki (Feist.).
Phœnicopsis elongatus (Morr.).
Stenopteris elongata (Carr.).

3. *Permo-Carboniferous Flora of Vereeniging.*—The conclusion to be drawn from the Vereeniging plants is that they belong to a flora which flourished in South Africa, India, South America, and Australia during some portion of the Permo-Carboniferous epoch. On the whole, it would seem probable that the age of the plant-beds corresponds most nearly with the Upper Carboniferous period as represented in Europe. It is of necessity difficult to attempt to

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[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

express the geological age or homotaxy of South African beds in terms of the geological chronology of the Northern Hemisphere, but the close correspondence of some of the Vereeniging types with Indian and South American species points to their correlation with the Karharbari beds of the Lower Gondwana system. The occurrence of such types as *Sigillaria*, *Bothrodendron*, and *Psygmophyllum* shows a closer correspondence between the South African flora and that of the Northern Hemisphere than occurs in the Indian vegetation. We have evidence of an overlapping or commingling of the northern and southern botanical provinces in South Africa and in South America that is not afforded by the Lower Gondwana floras of India and Australia.

Glossopteris Browniana (Brongn.). Under this head may be included, at least for present purposes, *G. indica* and *G. angustifolia*.
Gangamopteris cyclopteroides (Feist.).
Sphenopteris, sp.
Neuropteridium validum (Feist.).
Psygmophyllum Kidstoni, sp. nov.
Sigillaria Brardi (Brongn.).
Bothrodendron Leslei, sp. nov.
Noeggerathiopsis Hislopi (Bunb.).
Conites, sp.
Cardiocarpus, sp.
Phyllotheca, sp.
Schizoneura, sp.

A detailed account of the above species will be published in a forthcoming volume of the Annals of the South African Museum. The writer is indebted to the officers of the Geological Survey of Cape Colony for the opportunity of examining the collections from which these lists have been compiled.

VIII.—ON THE DISTURBANCE OF JUNCTION BEDS FROM DIFFERENTIAL SHRINKAGE AND SIMILAR LOCAL CAUSES DURING CONSOLIDATION.

By G. W. LAMPLUGH, F.G.S.[1]

UPON returning to the investigation of comparatively undisturbed Mesozoic strata, after having studied distortion structures produced by earth-movement in the older Palæozoic rocks, the author's attention has been frequently arrested by local disturbances of the original bedding which cannot be assigned to the agency of deep-seated earth-movement, but are clearly due to minor stresses arising from some local cause in tracts limited in extent, both horizontally and vertically.

These disturbances are most noticeable where thin bands of one kind of material are imbedded in thick deposits of another kind, and along the junctions where thick masses of different lithological character occur in stratigraphical sequence.

Examples of the first-mentioned condition are abundant in the Hastings beds of the Wealden formation, where thin layers of clay or shale interbedded with thick sands and sandstones are often disrupted into irregular patches and partly mixed with the inclosing sands. The second condition is frequently illustrated in junctions of the Lower Greensand with underlying clays, where strips have been torn from the irregular surface of the clay and dragged up for a few inches into the sands, as was seen in the recently widened railway cutting at Redhill and in the pit-sections at the Dover Colliery. Similar effects have often been supposed to denote the breaking up of the surface below the junction by erosive agencies, but this explanation is rarely adequate.

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[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

While some of these local disturbances may have been caused by unequal loading within limited basins of sedimentation, in the matter discussed by E. Reyer,[1] the author is of opinion that in most cases they may be assigned to local stresses resulting in part from the differential contraction of sediments of diverse composition while losing their water of sedimentation, and in part from their unequal yielding under equal superincumbent load. Masses of peat, sand, clay, and calcareous sediments accumulated under normal conditions must pass from the wet state to the consolidated or partly consolidated state with different time-rates and with different physical results; and we may expect to find signs of local tension and readjustment along the boundaries of such masses.

In thick wedges of strata which thin out rapidly, as, for example, in the Triassic rocks of many localities and the Wealden and Lower Greensand of the south of England, differential shrinkage may be responsible for many of the smaller vertical displacements by which the beds are readjusted. Faults are sometimes found to dwindle and die out downward, and in certain cases these may be explicable as the result of unequal contraction in masses of irregular thickness.

IX.—Photographs of Geological Interest in the United Kingdom.[2] Fourteenth Report of the Committee:

Consisting of Professor James Geikie (Chairman), Professor W. W. Watts (Secretary), Professor T. G. Bonney, Professor E. J. Garwood, Professor S. H. Reynolds, Dr. Tempest Anderson, Mr. Godfrey Bingley, Mr. H. Coates, Mr. A. K. Coomáraswámy, Mr. C. V. Crook, Mr. J. G. Goodchild, Mr. William Gray, Mr. Robert Kidston, Mr. J. St. J. Phillips, Mr. A. S. Reid, Mr. J. J. H. Teall, Mr. R. Welch, and Mr. H. B. Woodward.

THE Committee have to report that during the year 463 new photographs have been received, bringing the total number in the collection to 3,771. This exceeds by 50 the largest number of new photographs previously recorded in a single year, and the yearly average now reaches 268. About 60 additional photographs have been sent in since this report was written.

The usual geographical scheme is appended. Brecknock, Cardigan, Nairn, and Ross appear for the first time, and very substantial additions are made to Cheshire, Dorset, Norfolk, Yorkshire, Glamorgan, the Channel Islands and Scilly, Inverness, Sutherland, Antrim, and Louth. The following twenty-five counties are still entirely unrepresented :—Cambridge, Huntingdon, Rutland, Carmarthen, Clackmannan, Dumbarton, Dumfries, Kincardine, Kinross, Roxburgh, Selkirk, Carlow, Kildare, Kilkenny, King's County,

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[1] K.K. Geol. Reichsanstalt Wien, Jahrbuch, xxxi (1881), pp. 431-444.

[2] Abstract *of paper read* before the British Association, Southport, Section C *(Geology), September, 1903.*

Leitrim, Longford, Monaghan, Queen's County, Roscommon, Tyrone, Waterford, Westmeath, Wexford, and Wicklow.

The high standard mentioned in the last report is maintained, the photographs being usually taken in sets and with a definite geological aim. Mr. W. Jerome Harrison sends two large series taken to illustrate glacial phenomena on the Norfolk and Holderness cliffs. Mr. Morton and Mr. Howard contribute illustrations from Brecknock; Mr. R. H. Preston from the Scilly Islands; Mr. Guiton from Jersey; and Mr. Maidwell from the Nuneaton district. Mrs. Coomáraswámy has taken several series from the north of Scotland and of Ireland; Mr. Wright a useful set from Dublin; and Mr. Lamond Howie some interesting Scottish mountain photographs. The Croydon Natural History and Scientific Society continues to illustrate the geology of Surrey; Dr. Abbott that of Durham; Mr. Hopkinson that of Bedfordshire; and Mr. Hodson that of Leicestershire.

The members of the Committee have not been idle, as is testified by Professor Reynolds' series from Dorset, Gloucestershire, Somersetshire, Glamorgan, Antrim, Down, and Kerry; Mr. Bingley's sets from Cheshire and Yorkshire; Mr. A. K. Coomáraswámy's series from Ross, Sutherland, and Berwick; Professor Garwood's contribution from Westmorland; Mr. Teall's photographs from Hertfordshire; and Mr. A. S. Reid's continuation of his series from Eigg and Perthshire.

To all those contributors named and to the following the Committee desire to tender their warmest thanks for photographs received or help rendered: Mr. J. B. Scrivenor, Mr. C. M. Gillespie, Mr. Howard Fox, Mr. G. T. Atchison, Mr. A. Wheen, Mr. E. M. Wrench, Mr. H. A. Hinton, Mr. R. H. Rastall, Mr. C. H. B. Epps, Mr. F. Greenwood, Mr. A. A. Armstrong, Mr. W. G. Fearnsides, Mr. J. H. Baldock, Mr. N. F. Robarts, Mr. C. G. Cullis, Mr. Caradoc Mills, Mr. G. E. Blundell, Mr. H. W. Monckton, Mr. E. K. Hall, and Mr. H. B. Woodward.

A few photographs have been received for the duplicate series, but will be held over for the present. This collection has been sent during the year to natural history societies at Winchester and Croydon, and accounts of the work have been given by Mr. Whitaker.

	Previous Collection.	Additions (1903).	Total.
England	2,051	257	2,308
Wales	224	26	250
Channel Islands	15	23	38
Isle of Man	60	—	60
Scotland	326	96	422
Ireland	536	61	597
Rock Structures, etc.	96	—	96
Foreign	—	—	—
Total	3,308	463	3,771

The collection is stored at the Museum of Practical Geology, Jermyn Street, and the Committee wish to express their thanks to the Director and to Mr. Crook for the care taken of it and the space devoted to it.

The second of the three contemplated issues of the published series of photographs has been sent to subscribers. The issue consists of eighteen half-plates, four quarter-plates, and four whole plates, and it has been published in the form of mounted and unmounted prints and lantern-slides. The negatives were contributed by thirteen photographers, and the descriptions by twenty geologists. To all who have thus contributed to the success of the issue the Committee give their best thanks.

The process of selection for the third issue is well advanced, and it is hoped that publication will take place within this year.

The Committee are prepared to publish a second series if there is a demand for it. The number of names at present sent in is only about sixty, and at least twice that number would be required to put the issue on a possible financial basis. The first two issues of the first series show a small profit. The Committee intend to apply one-half to the purposes of the collection, and thus avoid calling upon the Association for any grant for a few years, while they are returning the other half to the subscribers in the form of additional photographs. The subscribers have already received an 'interim dividend' (rather a larger one than the present profits warrant) in the form of four whole-plate photographs and additional slides.

Applications by local societies for the loan of the duplicate collection should be made to the Secretary. Either prints or slides, or both, can be lent, with a descriptive account of the slides. The carriage and the making good of any damage to slides or prints are expenses borne by the borrowing society.

REVIEWS.

I.—Geological Survey of Canada. Robert Bell, M.D., Sc.D. (Cantab), LL.D., F.R.S., Acting Director. Annual Report (New Series), Vol. XII: Reports A, B, C, G, I, J, M, O, R, S. 1899. Plates and Maps. (Ottawa: S. E. Dawson, 1902.)

THE volume before us contains ten reports, as lettered above. Report A (224 pp.) was written while the previous volume to the one under review was still in progress, and is the work of the late Director of the Survey, Dr. George M. Dawson; it is dated January, 1900, and has already been issued as a separate pamphlet. This summary report brings again into prominence the geological and topographical investigations carried on by Mr. R. G. McConnell in the richly auriferous region of the Klondike. A somewhat full preliminary report upon the district is given. The geology of the gold region is said to be complicated; the rocks are separated into the following divisions, none of which can as yet be exactly correlated with formations previously described in British Columbia, the Yukon District, or Alaska. The order is *apparently ascending*—

Stratified and foliated rocks, mostly Palæozoic.	Indian River Series. Hunker Series. Klondike Series. Moose Hide Group (in part).
	TERTIARY.
Eruptive rocks.	Granites. Later eruptives.

The gravels along the creeks in which the gold is worked fall into five groups; beginning with the oldest, they are the *quartz-drift*, followed by the associated *yellow-gravels*, the *river-gravels*, the *terrace-gravels*, and the *valley-gravels*. Of these the *valley-gravels*, the *quartz-drift*, and the *terrace-gravels* have proved productive. Thousands of streams, it is stated, in the gold belt stretching for hundreds of miles from Atlin to the Klondike and farther to the north, still remain to be explored, and the work of the prospector will not be completed for many years. A map of the Klondike goldfields accompanies the report.

Next we have summaries of the work done in British Columbia, the Mackenzie and Saskatchewan districts, Ontario, Quebec, Hudson Bay (east coast), New Brunswick, and Nova Scotia; these abstracts anticipate to some extent the detailed reports following them. The first of these (Report B) is on the Atlin Mining District, British Columbia, by J. C. Gwillim, and contains an account of the drainage basin of Atlin Lake with the country to the east of it, "in all some 6,000 square miles of the extreme north-west corner of British Columbia." The district here defined has recently come into notice as a placer gold-producing area of much importance. The report begins with a description of the topography of the district surveyed, and this is succeeded by an account of its geological features, and especially of the pre-Glacial gravels with their gold contents. A contour-map, geologically coloured, and three plates illustrating the methods of working on the larger streams and in the pre-Glacial gravels, accompany the report.

Report C, by J. M. Bell, deals with the topography and geology of Great Bear Lake and of a chain of lakes and streams thence to Great Slave Lake. A description by Dr. A. E. Barlow of the rocks collected is given as an appendix.

Dr. R. W. Ells contributes a report (G) on the geology and natural resources of the area included in the map of the city of Ottawa and vicinity. The map is on a scale of one mile to an inch and embraces a total of 450 square miles, the city of Ottawa being taken as the central point.

The formations recognized in this area range from the Archæan to the Silurian, as follows:—

Medina Red Shales.
Lorraine Shales and Sandstone.
Utica Shale.
Trenton Limestone.
Black River Limestone.

Chazy Limestone.
Chazy Shale.
Calciferous, mostly dolomite.
Potsdam Sandstone.
Archæan.

The more recent fossils collected in the district were tabulated by Dr. H. M. Ami, and form a valuable appendix to the report. Some interesting plates, showing both natural and artificial sections in the Chazy, Trenton, and Black River formations, serve as illustrations.

Report I, by E. D. Ingall, contains an account of the iron-ore deposits along the Kingston and Pembroke Railway in Eastern Ontario, in portions of the counties of Frontenac, Lanark, Renfrew, and Leeds. A general map accompanies the report, showing the location of the deposits examined.

Another report (J), by Dr. Ells, treats of the geology of Argenteuil, Ottawa, and part of Pontiac counties, province of Quebec, and portions of Carleton, Russell, and Prescott counties, province of Ontario. The area included in the map, which is drawn on a scale of four miles to an inch, is not far short of 4,000 square miles. The formations met with south of the Ottawa River are the following:—

Utica Shale.
Trenton Limestone.
Black River Limestone.
Chazy Limestone and Shale.
Calciferous Dolomite.
Potsdam Sandstone.

Attention is given to the economic minerals, which include apatite, asbestus, graphite, iron, mica, barite, felspar, building stones, ochres, peat, and granites. An appendix by Dr. Ami, containing lists of fossils obtained from the formations along the Ottawa River, concludes this report.

Report M, by R. Chalmers, refers to the surface geology shown on the Fredericton and Andover quarter-sheet maps, New Brunswick, and deals with the character of the soils, whether these were formed by the disintegration and waste of the underlying rocks, or consisted of Boulder-clay or of the later modified deposits. The report also deals with the agricultural capabilities of the area and with the extent of the forests covering it. The coloured maps are drawn on a scale of four miles to an inch.

Report O appears to be of exceptional interest and value; it consists of "Notes on certain Archæan Rocks of the Ottawa Valley," by Professor A. Osann, of Mülhausen, Alsace, who, in the Autumn of 1899, made a series of geological excursions in that part of the province of Quebec north and east of Ottawa, in some of which he was accompanied by Dr. Ells and Mr. Ingall. "The object of these excursions was, on the one hand, to become acquainted with some of the principal types of gneisses and their associates, and on the other, and more especially, to study the technically important minerals apatite, mica, and graphite. Naturally, on account of the great variety of the gneisses and the enormous area covered by them . . . . it was necessary to select certain characteristic types. Their further geological study, and the determination of their relations, must wait for a special mapping of this highly interesting district. Relatively the longest time was given to the study of the apatite deposits." The report is illustrated in the text with outline figures of remarkable crystals of pyroxene, felspar, etc., as well as of rock-sections; there are also plates of a similar character.

In the next report (R) we have an account of the section of chemistry and mineralogy, by Dr. G. Christian Hoffmann, assisted by Messrs. Wait and Johnston. This report consists of analyses and descriptions of a great number of minerals submitted to the laboratory for identification.

The last report (S) describes the work of the section of mineral statistics and mines for 1899, and is drawn up by E. D. Ingall, with the assistance of T. C. Denis and J. McLeish.

The rapid growth of the mineral industries of Canada is pointed out, the increase of 1899 over 1898 amounting to nearly 11,000,000 dollars, or upwards of 28 per cent. The proportionate value of the different mineral products is striking. On comparison with the figures for 1898 it is found that in 1899 gold increased its lead over other economic minerals from about 36 per cent. to about 43 per cent., thus being by far the largest item, and with coal accounting for over 64 per cent. of the total. A further analysis of the figures for 1899 gives the following interesting data regarding the relative importance of the different products. Thus, gold amounts to exactly 42·88 per cent. The other metals account for about 16 per cent., or a total production of metals of about 59 per cent. The combustible class is credited with 24·65 per cent., structural materials with 12·44 per cent., and all other non-metallic products with the remainder, about 4 per cent.

A copious index concludes the report. ARTHUR H. FOORD.

II.—THE LAURENTIAN ROCKS OF CANADA.

DR. E. W. ELLS, writing[1] on the Geology of some parts of the Provinces of Quebec and Ontario, 1901, states that "much of what was formerly regarded as altered sediments in the Laurentian formations, north of the Ottawa, and so described in the earlier Reports, must now be accepted as altered igneous rocks. Under this head must be placed the greater bulk of the gneissic rocks, which form so large a portion of the Laurentian system, as well as much of the pyroxenic and felspathic rocks, in which are to be classed the great bulk of the white binary granites, or pegmatites, so often associated with the crystalline limestones. These limestones, however, with their associated bands of greyish quartzose gneiss, often very rusty in character, as also well-defined beds of whitish quartzite, may readily be assumed as representing true sediments in a very high state of metamorphism; to which may be added certain areas of reddish-grey, and sometimes black, gneiss; so that we have, if we consider the whole series under the head of Laurentian, two easily separable portions, viz., an altered igneous and an altered sedimentary series."

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[1] In the Annual Report of the Geological Survey of Canada, Report I, p. 16, 1899–1902.

In the same volume of Reports, Mr. A. Osann gives notes on certain Archæan rocks of the Ottawa Valley, translated by N. N. Evans, 1902, treating especially of gneisses, and of the occurrence of apatite, mica, and graphite. In the course of his description of the gneisses and their associated rocks, he gives a full description of the Eozoonal rock of Côte St. Pierre. It occurs just above the junction of the limestone with the gabbro, which constitutes the mass of the hill below, and appears to have resulted from contact metamorphism. "If Eozoon was an organic being, its hard parts, which are still preserved, certainly did not consist originally of diopside or serpentine, but were converted to the former by an act of metamorphosis" (p. 66, Report O).

Graphite is widely distributed in the granular limestone of Canada. It may, too, have had an organic origin, but has been modified by the same agency that changed the limestone into marble. It is highly probable that gaseous infiltration may have had to do with the formation of the veins of both phosphates and graphite, filling up cracks and fissures during the cooling and solidification of the ancient rock-surface.

T. R. J.

III.—The Palæontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California. By Ralph Arnold. Contributions to Biology from the Hopkins Seaside Laboratory of the Leland Stanford Junior University: No. xxxi. Reprinted from the Memoirs of the Californian Academy of Sciences, vol. iii. pp. 420, with 37 plates. 1903 (published 27th June).

THIS important memoir forms a "Dissertation presented to the Faculty in Geology of the Leland Stanford Junior University, for the Degree of Doctor of Philosophy."

Chapter i comprises: Topography; General Geology; Pliocene; Pleistocene; Post-Pleistocene Deposits; and Alphabetical List showing the Distribution of Species in the vicinity of San Pedro. Chapter ii: The Upper Pliocene and Pleistocene Formations of other localities on the Pacific Coast. Chapter iii: Faunal Relations (embracing a comparison of the fossil and living faunas of California with those of Japan); Description of Species; Bibliography; and Index. The species described are included under the following groups:—Cœlenterata (Anthozoa), Echinodermata (Echinoidea), Molluscoidea (Bryozoa and Brachiopoda), Mollusca (Pelecypoda, Scaphopoda, and Gastropoda), Arthropoda (Crustacea), and Vertebrata (Pisces). Mr. Wayland Vaughan has prepared diagnoses of the new Anthozoa, which have been found in the San Pedro deposits, whilst Dr. W. H. Dall and Mr. Paul Bartsch have rendered assistance in describing those shells belonging to the family of the Pyramidellidæ. By far the larger part of the work (pp. 95–343) is concerned with the mollusca, and here we must congratulate Dr. Arnold on the thoroughly systematic manner in which he has treated this part of his monograph, especially with regard to nomenclature, which has evidently received very considerable attention. We, however, would still prefer to adopt *Nuculana* for *Leda*, *Volsella* for *Modiolus*, *Gari* for *Psammobia*, *Cuspidaria* for *Neæra*, *Volvulella* for *Volvula*, and *Bullinella* for *Cylichna*. Out of the 37 plates illustrating the volume, 21 are devoted to shells, all admirably depicted by photo-lithography; the remainder consist of sections, map, and several photographic views of the San Pedro country, exhibiting the Tertiary and post-Tertiary formations, as well as some interesting beach-structures which skirt the Pacific shores of the region in question. An index of specific names, arranged under their genera, concludes this useful and well-compiled work.

IV.—CATALOGUE OF THE COLLECTION OF LONDON ANTIQUITIES IN THE GUILDHALL MUSEUM. 8vo; pp. xx, 404, with 100 plates. London, 1903. Price 1s.

THIS Catalogue opens with an Introduction, which is in brief the history of the Collection. It is written by Mr. Charles Welch, who is also responsible for the plan of the work. The Catalogue has been skilfully condensed from the manuscript lists by Mr. G. F. Lawrence, who has added the accessions of the past three years. Judging by the improvement in the cases during that period, we believe that Mr. Lawrence has done excellent work in the Museum while preparing the Catalogue. Though not of much interest to geologists beyond the flint implements undoubtedly found in London, we call attention to this volume because of the quite remarkable way in which it is illustrated. A hundred meisenbach plates, containing 1,100 figures of London antiquities, is undoubtedly a publication of which Londoners and the City Fathers may well be proud, and which cannot fail to be of the greatest interest and utility.

CORRESPONDENCE.

FOSSIL INSECT FROM THE COAL-MEASURES, NORTH STAFFORDSHIRE.

SIR,—It may be of interest to your readers to know that I lately found a beautifully preserved wing of what is believed to be closely related to *Lithomantis carbonarius* (H. Woodw.) in a rich plant-bed at Foley, near Longton, North Staffordshire. The geological horizon was the Peacock Marl (i.e. the marl overlying the Peacock Coal), and is therefore near the top of the workable Coal-measures.

I may add that it is the first fossil insect obtained from the Pottery Coalfield, and I am indebted to Dr. H. Woodward, F.R.S., for suggesting the probable name of the specimen.

DARENTH TERRACE, BASFORD PARK,
STOKE-ON-TRENT.

JOHN T. STOBBS.

BORINGS OF *SAXICAVA* 300–450 FEET ABOVE THE SEA.

SIR,—During the earlier part of this month, when examining the ocks of Carleton Hill, six miles S.S.W. of Girvan, I discovered number of *Saxicava* borings in the rock at from 300 to 450 feet ove sea-level. The borings have been made into bits of *limestone* ccurring in the igneous rocks of which this hill is mostly composed.

I know that the land-shell *Helix aspersa* gets the credit of being le to bore holes in *limestone*, but although I have known this snail r many years, I have never seen an instance of its having bored hole; it congregates in clusters into ready-made crevices.

However, to return to the Carleton Hill borings, I pared away out two inches from the surface of one of the bits of limestone, d found the molluscan borings ramifying through the stone exactly the manner in which they occur in limestone bored by *Saxicava* the present day.

I know that no geologist will remove these ancient 'Nilometers,' though they may not escape the clutches of the mere 'specimen-unter.'

The occurrence of borings in the rock of Carleton Hill is quite in eeping with the evidence afforded by the sea-shells obtained in the yrshire *drift* up to more than twice the height of 450 feet, a detailed escription of which has been published by the Geological Society f Glasgow.[1] J. SMITH.

MONKREDDING, KILWINNING.
September 26, 1903.

SECTION OF THE THAMES ALLUVIUM IN BERMONDSEY.

SIR,—Will you kindly allow me to correct a misprint in the aper "On a Section of the Thames Alluvium in Bermondsey." n the section on p. 456 the top line is stated to be "sea-level"; is should be "street-level." The actual level of the street here is bout 15 feet O.D. S. HAZZLEDINE WARREN.

CONNAUGHT AVENUE, LOUGHTON, ESSEX.
October 14, 1903.

OBITUARY.

ALPHONSE FRANÇOIS RENARD.

BORN SEPTEMBER 26, 1842. DIED JULY 9, 1903.

AMONG the geologists of the Continent there was probably none so idely known personally in this country as Professor Renard. ence the announcement of his death has brought with it to us, not nly regret for the loss which science has sustained, but sorrow for he premature decease of one who was familiar to a large circle s a pleasant companion and to not a few as a valued friend. e was born at Renaix, in Belgium, but, though a native of that ountry, he received his scientific training in Germany, if the riter's memory serves him, at the Jesuit seminary of the Abbey f Maria Laach, before that institution was dissolved. Not mprobably the geological attractions of the volcanic district of the

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[1] *Transactions* Geological Society of Glasgow, suppl. to vol. xi.

Eifel largely influenced the direction of his youthful studies. As an original observer he was first known by his work among the plutonic rocks of the Ardennes, to the investigation of which he applied with much success the modern methods of petrographical research. With the co-operation of C. de la Vallée-Poussin, of the University of Louvain, he wrote in 1876 an important monograph on these rocks, which was published as a "Mémoire Couronné" by the Belgian Academy, and which at once established his reputation as an accomplished petrographer. Subsequent papers by him dealt with other aspects of Belgian geology, particularly with the whetstones, phthanites, and dolomites. Prominent among these contributions was his masterly discussion of the metamorphism of that region, wherein, while confirming the general accuracy of the earlier observations of Dumont, he dwelt especially upon the regional character of the alteration, which he regarded as connected with the intense mechanical movements to which the rocks of the whole region had been subjected. It is true that in more recent years he was disposed to question the validity of this conclusion, at least with reference to some part of the metamorphism, which he was led to think might rather be due to the protrusion of igneous rocks still concealed beneath the present surface of the ground. In this change of opinion, however, he was strongly opposed by Professor Gosselet.

Renard's petrographical researches among the rocks of his native country united in an eminent degree the work of the mineralogist, the chemist, and the microscopist. They were marked by a fulness and accuracy of detail, and at the same time by a breadth of treatment, which showed that he studied the problems of rock-history in the field, as well as in the laboratory. Accordingly, when the materials brought home by the "Challenger" expedition came to be distributed among capable experts, it was decided that those which required petrographical qualifications could not be placed in better hands than those of Renard. During a succession of years, in association with Sir John Murray, he published a series of interesting and important papers on the deposits of the ocean-floor. Ultimately these observations were extended and combined in the great monograph on "Deep-sea Deposits," published in 1891 as one of the massive quarto volumes of the "Challenger" Reports. This work will always be looked upon as a classic treatise in Oceanography, and as practically the starting-point of all subsequent research on the subject. Of special interest to geologists were the detection and description of cosmic dust, in metallic grains and bronzite chondres, the recognition that minute crystals of a zeolite are formed on the sea-bottom at a temperature of 32°, and the copious discussion of the origin and distribution of phosphatic and glauconitic deposits on the present bed of the ocean.

Educated for the priesthood, Renard took holy orders and intended to enter the Society of the Jesuits. Until only a few years ago he wore the clerical dress, officiated in the offices of the Church, and was known everywhere as an Abbé. But he passed before taking the final step that would have completed his adhesion to the Jesuits. To his intimate friends he would now and then disclose an unexpected breadth of view in religious questions. As years passed, the longing for mental freedom grew ever stronger, until at last it overmastered all the traditions and associations of a lifetime, and he finally separated himself from the Church of Rome. Had he contented himself with the announcement of this change of opinion, the outcry against his apostasy in such a country as Belgium would doubtless in any case have been loud and long. But he marked his secession from the clerical order by marrying—an act which could not but intensify the persecution. Many bitter and unworthy reproaches were heaped upon him, and many old friends now shunned him. A man of his gentle and kindly nature must have keenly felt the misrepresentation to which he was subjected. To those who still held to his friendship, he said that he had done what after long meditation he believed to be right, and that the consciousness of his rectitude of aim supported him in the trial. But the hand of death was already upon him. An insidious and fatal disease, of which many years ago he had premonitions and for which he had undergone several operations, now spread through his body and rapidly brought his life to a close on the 9th July, 1903, at Brussels.

Renard held for many years a professorship in the University of Louvain and a Conservatorship in the Royal Museum of Natural History at Brussels. These appointments he vacated when he succeeded to the chair of geology in the University of Ghent, which he retained up to the time of his death. The members of the Geologists' Association were greatly indebted to Professor Renard for much kindness and valuable assistance on the occasion of their visit to the Ardennes in August, 1885. The value of his scientific work was recognized in this country by the Geological Society when it awarded to him the Bigsby Medal in 1885, and by the Royal Society of Edinburgh when it elected him into the select number of its honorary Fellows. From his frequent visits to this country he learnt to speak English fairly well, while his early training in Germany gave him fluency in the language of that country. His genial face, beaming with good-nature, will long be missed at the meetings of the British Association, which he frequently attended.

A. G.

JOHN ALLEN BROWN, J.P., F.G.S., F.R.G.S.

Born September 3, 1831. Died September 24, 1903.

By the death of Mr. John Allen Brown, an earnest student of geology, and more especially of the latter post-Pliocene deposits of the Thames Valley, has been removed from our midst.

He was born in London 3rd September, 1831, succeeded his father[1] as diamond merchant, and some forty years ago settled in

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[1] John Brown (1797–1861), one of the founders of the Ethnological Society, took a keen interest in geographical, especially Arctic, exploration, making large collections in illustration thereof. He was conspicuous as an advocate of expeditions in search of *Sir J. Franklin, and defined* the area which that explorer was ultimately found to *have reached, but was not listened* to at the time.

Ealing. From his father he inherited a taste for geographical research, and he joined the Royal Geographical Society in 1861; but incited by the investigations made by General Pitt-Rivers (then Colonel Lane Fox) in 1869, the results of which were published in 1872,[1] he turned his attention to the drift deposits in north-west Middlesex, for which the numerous excavations for building purposes then beginning in Ealing afforded the requisite material.[1] His earliest scientific papers were, however, on general subjects and given before the Ealing Microscopical and Natural History Society, of which he was one of the founders and its president from 1882–83.

In 1883 he laid before the members of the Geologists' Association, both on an excursion and in a paper read to that body, the evidences that appeared to him indicative of ice-action on the summit of the high ground to the north of Ealing. To this subject he frequently recurred in subsequent papers.

A little later he discovered that patches of gravel were found at intervals up to the top of Castlebar Hill, a situation in which they had not then been mapped by the Geological Survey.

Primæval Man and his Implements was the subject, however, to which he was most devoted, and from 1885, when he read his paper on "The Earliest Men of Ealing" to the local Society, his scientific publications were almost exclusively confined to that theme.

In a series of communications to various Societies during the next two years he demonstrated the existence of a "Palæolithic floor" in the neighbourhood of Ealing and Acton, comparable to the ones previously described for north-east London by Mr. Worthington G. Smith and Mr. Greenhill. The substance of these papers was gathered together and extended to form his work "Palæolithic Man in N.W. Middlesex," issued in 1887.[2]

He continued to work at this line of research for the rest of his life, and his latest paper, read before the Ealing Natural Science Society in 1902, was on "Recent discoveries in relation to Prehistoric Man in Ealing."

He passed quietly away at his Ealing home on 24th September, 1903, after a long and painful illness.

His portrait in oils hangs in the Reading-room of the Public Library at Ealing, in the establishment of which he took a leading part, becoming first Chairman of the Committee.

Mr. Brown became a Fellow of the Geological Society in 1886, and was made a Justice of the Peace in 1894.

His private collection of geological objects was extensive, but the assemblage of implements which he brought together is remarkably fine, and it is to be hoped that this will not be allowed to melt away, as collections so often do when the loving hand of the owner is removed and they are not transferred, as they always should be, to the safe keeping of some public body.

B. B. W.

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[1] Quart. Journ. Geol. Soc., vol. xxviii.

[2] His other chief work "The Chronicles of Greenford Parva" is of great topographical interest, but is not connected with geology.

THE
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No. XII.—DECEMBER, 1903.

ORIGINAL ARTICLES.

I.—A New Egyptian Mammal (*Arsinöitherium*) from the Fayûm.

(PLATES XXIII AND XXIV.)

FROM time to time during the last two years brief accounts of a remarkable series of vertebrate remains, from the Middle and Upper Eocene of the Fayûm district of Egypt, have been published in the pages of this Magazine. The species hitherto described include a number of highly interesting animals, but of the most extraordinary of all, viz. *Arsinöitherium Zitteli*, no figure has yet appeared in this Journal. We are therefore glad to take the opportunity of remedying this omission by availing ourselves of the kind permission of the Editor of *The Sphere* to reproduce two photographs of the skull of this animal, which appeared in the pages of that journal on September 12th, 1903, as illustrations of a short article by Professor E. Ray Lankester, which is the first account of *Arsinöitherium* published in this country, and from which some extracts are given below.

Arsinöitherium Zitteli was found about two years ago by Mr. H. J. L. Beadnell, who published in Cairo a preliminary notice with figures of the type skull and some other specimens.[1] Since then more complete specimens have been found both by him and by Dr. C. W. Andrews, and it is one of these, now in the British Museum of Natural History, Cromwell Road, London, of which photographs are given. A complete account both of this and of the other extinct animals of the Fayûm will be shortly published in a monograph, which will include figures and descriptions of the material both in London and Cairo.

The deposits in which these remains occur have been described by Schweinfurth, Beadnell, Blanckenhorn, and others. The lower beds, consisting mainly of clays, sandstones, and limestones, are for the most part of marine or littoral origin, while the upper beds, from which *Arsinöitherium* and *Palæomastodon* were collected, consist mostly of current-bedded sands of fluviatile or estuarine origin; in places these include great quantities of silicified tree trunks, which no doubt were brought down by the same stream which bore to their present resting-places the carcases of the animals whose remains are now being found. These deposits probably mark the position of the estuary of a great river, coming from a more or less southerly direction and draining a land area the fauna of which we are only now beginning to know. The first land mammals were collected less than three years ago, but, as mentioned in the following extracts from Professor Lankester's article, the work is still going on:—

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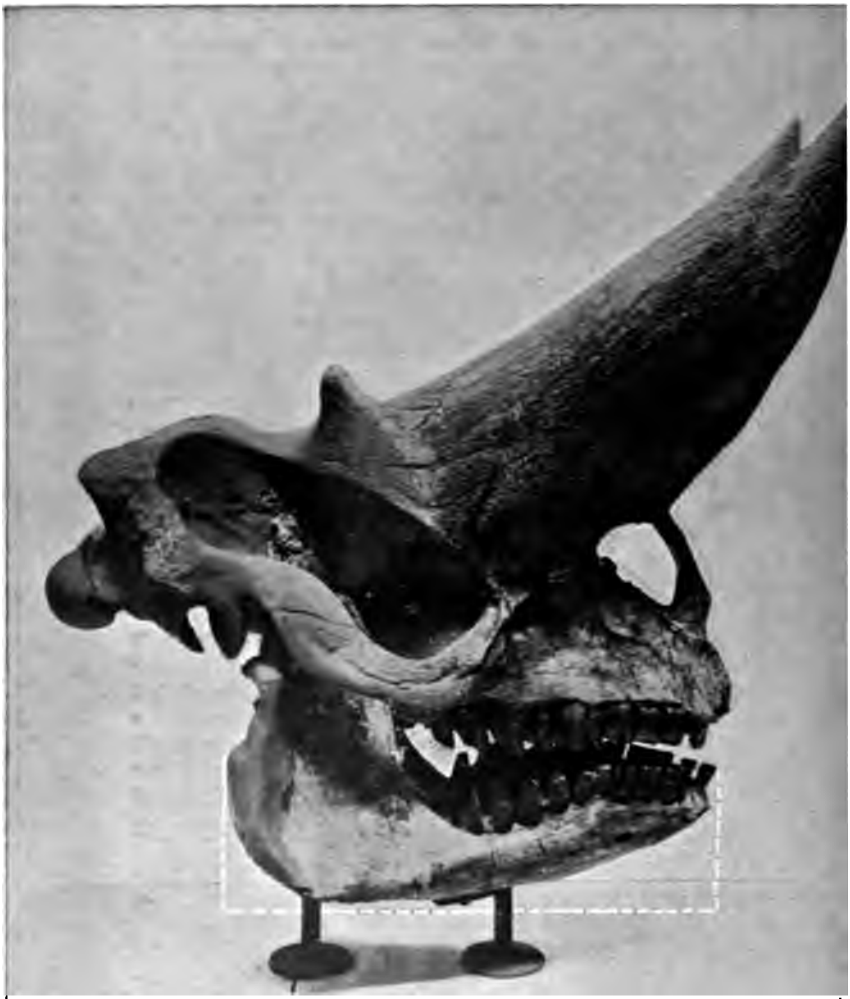
[1] Survey Department Public Works Ministry, Cairo, 1902. A preliminary note on *Arsinöitherium Zitteli*, Beadn., from the Upper Eocene strata of Egypt. By Hugh J. L. Beadnell, F.G.S., F.R.G.S.; 8vo; pp. 1–4, pls. i–vi.

"The officers of the Egyptian Survey have continued their exploration of the region, and in addition Dr. Andrews has also been sent both last year and again this year in the spring months by the Trustees of the British Museum to dig in the sands of the desert in search of further remains of this marvellous assemblage of strange and long-since vanished animals. The journey into the desert is not a light task, as the best localities discovered are as much as three days' march from any supply of water. Last year Mr. Beadnell, of the Egyptian Geological Survey, discovered what is perhaps the most astonishing of all the monsters unearthed in the Fayûm. It is as big as a large rhinoceros, and at first sight the skull suggests an affinity with that animal. It has two enormous horns growing from the nasal bone, but these are not, as in the rhinoceros, horns of a horny, fibrous material; they are actual bony outgrowths covered in life with blood-vessels and skin, and probably hair, as are the horns of the giraffe. Possibly the tips of these two great horns may have been protected by a sheath of horny matter, like a cow's horn. To this monster Mr. Beadnell has given the name *Arsinöitherium*, in honour of the Egyptian queen, Arsinöe, who had a palace in the Fayûm in a region near the Lake Moeris, which was larger in those days and surrounded by a fertile zone, degenerated into sandy waste since her time.

"Since Mr. Beadnell's discovery of the first skull of *Arsinöitherium*, some six or seven more or less complete skulls have been dug out. The most complete, having the lower jaw actually belonging to it in place, is that shown in the photograph. It was recently brought home by Dr. Andrews from Egypt, and after cleaning, strengthening, and the restoration of parts deficient on the left side by modelling from the right side, is now exhibited in the central hall of the Natural History Museum in Cromwell Road.

"It will be seen from our photographs that besides the huge pair of horns projecting forwards above the nostrils, *Arsinöitherium* had a smaller pair of horns lying further back upon the skull.

"The nearest allies, it seems, of the great horned beast of the Fayûm are to be found in a set of animals of which the best known has the name *Dinoceras*, discovered in Wyoming, North America, in sands of the same age as those of the Fayûm. These *Dinoceras* forms have been obtained in some abundance, and were made the



Profile of Skull of *Arsinoïtherium Zitteli*, Beadn.

Upper Eocene, Fayûm, Egypt.

[Reproduced by permission of the Directors of the Sphere.]

subject of a monograph by the late Professor Marsh, of Yale. They are as large as a large rhinoceros, and have as many as three pairs of horns; none, indeed, quite so big as the front pair of *Arsinöitherium*, but often of respectable size. Many kinds are known, and the complete skeleton has been put together. They form a group known as the Amblypoda, and it is recognised as characteristic of this group that the feet and limb bones are similar in character to those of elephants. The teeth are very different from those of *Arsinöitherium*. A full-sized model of a complete skeleton of a *Dinoceras* is exhibited in the east gallery of the Natural History Museum. It is probable that the Amblypoda and *Arsinöitherium* are representatives of a group of great mammals which sprang from ancestors common to them and to the elephants—before the peculiar tusks and the trunk of the elephant had been developed. The hollow brain-case of *Arsinöitherium* has enabled us to study the shape of its brain by means of casts, and this will throw light on its affinities with elephants and *Dinoceras*.

"The question naturally arises as to what was the special use to *Arsinöitherium* of its two huge horns. The use of horns is in almost all cases either for defence against animals of prey or for those fierce contests between the males of a species in which the victor becomes lord of a number of females. Possibly both purposes were served by the horns of the *Arsinöitherium*.

"The skulls and bones of *Arsinöitherium*, described by Mr. Beadnell, belong to a single species to which he gave the name *A. Zitteli*, after Professor Zittel, of Munich. The lower jaw of this species is 1 ft. 8 in. in length. To this species belongs the specimen figured in the photograph, and it is a sufficiently huge and astonishing monster. But Dr. Andrews has this year brought back from the Fayûm a lower jaw of an *Arsinöitherium*, which is one-third as large again, namely, 2 feet in length (73·5 cm.). There is no doubt that this is a distinct and larger kind of *Arsinöitherium*, much bigger than the biggest existing rhinoceros. I name it *Arsinöitherium Andrewsii*, in recognition of the remarkable ability, courage, and perseverance shown by Dr. Andrews in the elucidation of the fossil mammals of the Fayûm."

It may not be inappropriate to mention that for the carrying out of Dr. Andrews' last expedition to the Fayûm, which resulted not only in securing a valuable series of vertebrate fossils, but the especially fine and complete head of *Arsinöitherium Zitteli* and the jaw and portions of the cranium of *Arsinöitherium Andrewsii*, the National Museum is indebted to the liberality of that enthusiastic naturalist W. E. De Winton, Esq., F.Z.S., for some time past the very able Acting Superintendent of the Zoological Society's Gardens, Regent's Park.

EXPLANATION OF PLATES XXIII AND XXIV.

Plate XXIII.—Profile of skull of *Arsinöitherium Zitteli*, Beadn., from the Upper Eocene of the Fayûm, Egypt.

The dotted white line on this Plate indicates the extreme length of the mandible, viz. 20 *inches*.

Plate XXIV.—Front view of skull of *Arsinoïtherium Zitteli*, Beadn. Upper Eocene, Fayûm, Egypt.

The dimensions of the skull here figured are approximately as follows:—

	cm.
Extreme length from occipital condyle to tip of horn	99
.. .. of snout	76
Width between outer ends of occipital condyles	25
Width at zygomatic arches	33·5
Width between tips of small horns	26
Length of mandible ... ... about	53·5

The dimensions of the type of *Arsinoïtherium Andrewsii*, Lankr., are roughly:—

	cm.
Length of mandible	73
.. lower molar series	23
.. premolar series	14
.. upper molar series	23·5

The above specimens have been presented to the Trustees and are now exhibited in the Great Central Hall of the British Museum (Natural History), Cromwell Road, London, S.W.

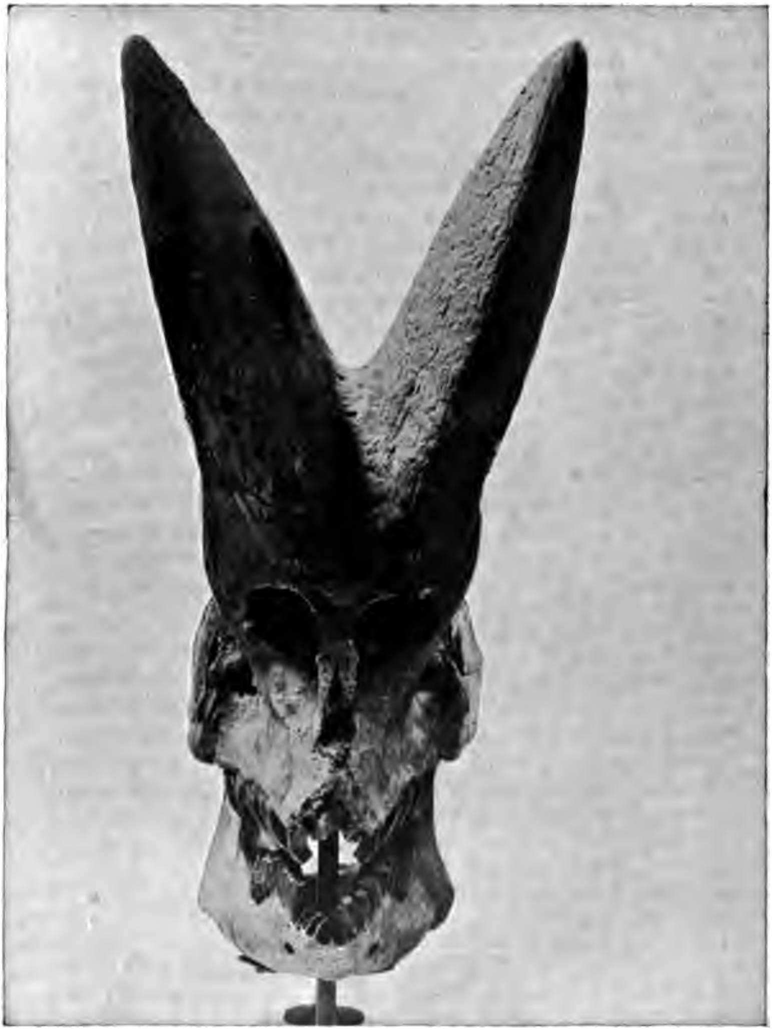
II.—The New Geological Museum at Cambridge.

By F. R. Cowper Reed, M.A., F.G.S.

THE Geological Department at Cambridge is at length provided with adequate accommodation by its transference to the new Sedgwick Memorial Museum. The portion of Cockerell's Building formerly occupied by the Woodwardian Museum has been vacated and put at the disposal of the University Library; and the well-known name is only perpetuated in a special portion of the exhibition galleries in the new building containing the founder's collection.

The Sedgwick Museum is the second Geological Museum at Cambridge which has been erected mainly through the liberality of the public. For, when in 1835 it was decided by the University to build a museum for geology, the sum of £23.400 was collected by public subscription, and to this was added £4,000 of Woodwardian Trust money. Cockerell's Building was erected with the help of these funds, and to the geological collections were assigned the two lower floors. The inadequacy of this accommodation, owing to the growth of the department and the increase in the size of the collections, has been only too apparent for many years. On the death of Professor Sedgwick in 1873 it was decided that his memorial should take the form of a new and larger museum; and in that year a public subscription was opened for this purpose, and a sum raised which ultimately amounted to over £28,000. The public recognition of the value of the Geological Department at Cambridge has thus been shown in a very substantial and liberal manner on two occasions.

After a long series of disappointments and difficulties the indefatigable energy and perseverance of Professor Sedgwick's successor, Professor T. McKenny Hughes, have triumphed over the countless obstacles which hindered the realisation of the scheme. The history of the efforts which have been made to find acceptable plans need not here be given, but it should be mentioned that the



Front view of Skull of *Arsinöitherium Zitteli*, Beadn.

Upper Eocene, Fayûm, Egypt.

[Reproduced by permission of the Directors of the *Sphere*.]

plans published by Mr. H. Woods as accepted in 1893 (*Natural Science*, vol. iii, p. 451) are not those which have been carried out, and the site has also been changed from the north to the south side of Downing Street.

The architect of both that proposed building and of the present one is Mr. T. G. Jackson, R.A., and he has had the difficult task of designing a museum which shall satisfy the needs of the Geological Department and the requirements of various University syndicates. The result is now ready to be judged; and, at any rate, the staff and students have good reason to be well pleased with their ample accommodation, and the collections will now be adequately exhibited as soon as sufficient table-cases are provided. The building is situated at the north-east corner of Downing College grounds, and consists of two wings meeting at the corner of Downing Street and Downing Place. The main wing has a frontage of 176 feet to Downing Street, and the other wing extends for the same distance along Downing Place. The court of which these wings form portions of two sides will ultimately be enclosed by the new Law Library, the Botanical Laboratory, and other University buildings. The main entrance to the Museum is from the court; a double flight of steps leads up to the first floor, on which are the palæontological collections. Each wing consists of three floors, with attics in the roof above. In the main wing at the west end of the ground floor there are the rooms for the unpacking, preparation, and setting-up of specimens, with the apartments for the curator and attendants. Shut off by folding doors from this portion is the Museum of Economics and two small research-rooms; while in the adjoining wing on the same floor are the Museum of Models and Appliances, and the principal lecture-room, capable of accommodating a class of 120 students. A special students' entrance and staircase to the floors above are placed at this point.

The first floor, to which access can be obtained directly from the court by the double flight of steps, or by an inside main staircase leading out of the Museum of Economics, is devoted to the palæontological collections, which are arranged stratigraphically in a series of bays along each side, formed by upright cases glazed above and with tiers of drawers below. Each bay is designed to contain a table-case of the ordinary type or a special show-case, while the larger specimens and additional cabinets will be arranged down the middle of the galleries. But this scheme cannot, unfortunately, be carried out at present in its entirety, owing to the funds granted by the University being insufficient by about £2,800 to provide the requisite new cases. The arrangement and display of specimens will, therefore, have to be left for the present unsatisfactory and incomplete.

The Downing Street gallery contains the Mesozoic and Tertiary fossils; its fittings and cases are of mahogany. The other wing, which has oak cases and fittings, is occupied by the Palæozoic fossils, and at its extreme end, beyond two bays devoted to Woodward's historic collection, are the Professor's private room and board-room.

At the junction of the two galleries is set the bronze statue of Prof. Sedgwick—the last work of the late Mr. Onslow Ford, R.A. The Professor is represented as standing with his geological hammer in one hand and a slab bearing the Cambrian trilobite, *Angelina Sedgwicki*, in the other.

The second floor has the western end of the Downing Street wing occupied by a well-filled library, fitted with oak shelves and book-cases through the liberality of the late Master of Trinity Hall, whose benefaction also permitted much extra ornamentation to be added to the exterior of the building. Class-rooms for palæozoology and palæobotany, private rooms for members of the staff, and a special room for the students' series of rocks and fossils are also placed on this floor in the main wing, while the Museum of Petrology, the petrological laboratory and class-room occupy the other wing.

The attics above provide space for storage of duplicate and supplementary collections, rooms for special research, lavatories, etc.

The materials which have been used in the construction of the Sedgwick Museum are very varied, but the general effect of the exterior is given by the purplish bricks made of the Weald Clay of Cranley in Surrey, mixed with 'breeze.' Bricks of a bright red colour from the Eocene clay of Castle Hedingham, and also from the Eocene beds of Bracknell in Berkshire, are here and there introduced round the arches of the windows and in other parts. The outside dressings are of Clipsham Stone from the Inferior Oolite of Rutland. Internally the local white bricks from the Gault form the mass of the building: Ancaster freestone is employed for the inside mouldings; and the Caithness Flags and the Purbeck-Portland passage beds have furnished much of the material for the staircases. Granite from Guernsey supports the internal iron columns, and Coal-measure sandstone from Idle, near Bradford, constitutes the templets on which the girders rest. The roof is covered with tiles made from the Upper Coal-measure clays of Stoke-upon-Trent. Materials obtained from many other localities and formations are used in the building, and make it in itself quite a museum of economic geology.

III.—NEW CARNIVORA FROM THE MIDDLE MIOCENE OF LA GRIVE-SAINT-ALBAN, ISÈRE, FRANCE.

By DR. C. I. FORSYTH MAJOR, F.Z.S.

VIVERRIDÆ.

PROGENETTA CERTA, sp.n.

THIS is the *Progenetta incerta* of Depéret, which requires a new name, as it is far from identical with the *Mustela incerta*, Lartet, from Sansan, with which Depéret identified his specimens from La Grive.

Depéret describes and figures an inferior right m. 1, and a right maxillary portion, exhibiting the two posterior premolars, the anterior molar, and part of the alveolus of m. 2.[1] The specimen in the British Museum before me (M. 5555) is a portion of the right mandibular ramus with m. 1, p. 1, p. 2 in place, and the empty alveoli of the two anterior premolars. The French writer does not give the dimensions of the lower molar, the figure of which (pl. i, fig. 19) agrees in size and in shape with the corresponding molar in the British Museum. The principal cusp of the latter specimen is slightly lower, this tooth being more worn than the one in the Lyons Museum. Of the three cusps forming the talon, the one situated behind the interspace of the other two is the smallest; the external one is the highest of the three. The two premolars show, besides the principal cusp, a very low cingulum cusp at their anterior and posterior end, as well as a somewhat stronger cusp, which is more developed in the posterior premolar, above and in advance of their posterior cingulum cusp.

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[1] Arch. Mus. Hist. Nat. Lyon, vol. v, pp. 34–36 (Extr.), pl. i, figs. 18–19 (1892).

The '*Mustela incerta*' of Sansan has been classed in turn with the Mustelidæ and the Viverridæ. Filhol[1] comes nearest to the truth when he insists on its having more analogy with *Cephalogale.* After close examination of the description and figure of the lower carnassial of *Mustela incerta,* given by Gervais,[2] I have no hesitation in declaring it to be a member of the true Canidæ, although different generically from *Canis.*

The *Progenetta* of La Grive has *real* affinities with other known fossils. On the one hand with *Ictitherium robustum* (Nordm.). Although this has been denied by Depéret, he admits it indirectly[3] by declaring the upper sectorial of his *Progenetta* to be identical in shape with the one figured by Gervais,[4] which he believes to represent the *Mustela incerta* from Sansan, whereas, as expressly stated by Gervais, it is one of the types of Nordmann's *Thalassictis* (*Ictitherium*) *robusta* from Bessarabia.

On the other hand, the *Herpestes crassus,* Filh., from La Grive, presents such close affinities with *Progenetta* that it will have to be classed as a species of the latter. As regards the small form of '*Herpestes crassus*' described and figured by Gaillard,[5] I fail to make out any noteworthy differences, except of size, between this form and *Progenetta certa.* The one described under the same name (*Herpestes crassus*) by Depéret,[6] besides being larger than Gaillard's specimen, differs from the latter in the same characters which distinguish it from *Progenetta certa*; in Depéret's specimens the talon as well as the internal cusp of m. 1 are higher and the premolars are slightly more complex.

My conclusion is, therefore, that we have, so far, three species of *Progenetta* at La Grive, viz., (1) *Progenetta certa,* sp.n. (*Progenetta incerta,* Dep.); (2) *Progenetta crassa* (Filh.) (*Herpestes crassus,* Filh.); (3) *Progenetta Gaillardi,* sp.n. (*Herpestes crassus,* Gaill.).

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[1] H. Filhol, "Etudes sur les Mammifères fossiles de Sansan": Ann. Sc. Géol., xxi, pp. 95–96 (1891).

[2] Zool. Pal. Fr., 2nd ed., pp. 221–222, pl. xxiii, fig. 3 (1859).

[3] Op. cit., p. 35.

[4] Op. cit., p. 222, text-fig. 24.

[5] Arch. Mus. Hist. Nat. Lyon, vol. vii, pp. 60–62, pl. ii, figs. 1, 3 (1899).

[6] *Arch. Mus. Hist. Nat. Lyon,* vol. v, pp. 31–33, pl. i, figs. 14–17 (1892).

	Measurements in millimetres.		
	Pr. certa.	*Pr. crassa.*[1]	*Pr. Gaillardi.*[2]
From posterior margin of m. 1 to anterior alveolar margin of p. 4	56	—	—
Length of m. 1	17·5	13–15	11·5
,, p. 1	14·5	11–13	9·5
,, p. 2	14	10·5–11	9
,, alveolus of p. 3	10·5	9·5	7
,, ,, p. 4	3·5	—	3
Height of mandibula below m. 1 (internal side)	18	20	15

LEPTOPLESICTIS, gen. nov.

The new genus here proposed is founded on five more or less complete mandibular rami (Brit. Mus. M. 5308; M. 5552*a–e*), ascribed to two species, one of which has been described by Gaillard[3] under the name of *Herpestes Filholi*.

In the slenderness of the teeth *Leptoplesictis* approaches the genus *Stenoplesictis* from the French Phosphorites; but its other characters assign to it decidedly a position within the Viverridæ, whilst *Stenoplesictis*, as pointed out by Schlosser, is on the border-line between the latter family and the Mustelidæ.

I have, in this place, nothing to add to Gaillard's excellent description of the larger of the two species, *Leptoplesictis Filholi* (Gaill.), which is distinguished from the smaller one, *Leptoplesictis minor*, sp.n., by the markedly higher ramus ascendens, the anterior border of which is also more vertical, as well as by the larger size. The dimension between the posterior alveolar margin of m. 1 and the anterior of p. 4 is 21·5 mm. in *L. Filholi*, against 18 mm. in *L. minor*, B.M. (M. 5552*b* and *c*).

MELIDÆ.

TROCHARION ALBANENSE, gen. et sp. nov.

A portion of a right mandibula, bearing the posterior premolar and the two molars, belongs to a member of the Melidæ approaching *Mephitis* with its allies, and the Javan *Mydaus*. The teeth are low, with their cusps less pointed than in the American Skunks, but not so blunt as in the Old World genus. P. 1 is an unicuspid, conical, rather thickset tooth, with a diminutive basal cusp anteriorly, and a posterior transverse basal cingulum. The anterior margin of the principal cusp presents a sharp ridge; the posterior is broad. The first molar resembles the corresponding tooth of *Mephitis*; however, in spite of the cusps being lower than in the American Skunks, the internal margin of the crown, between the cusps, is more raised, with the result that in the fossil there are not two openings on the internal side, and we have the unusual feature of an anterior pit, similar to but less deep than the pit of the talon.

The posterior molar is oblong in shape and less reduced than in the Skunks and in *Mydaus*; it has two roots; there is a distinct talon, provided with a cusp on the internal side, and separated from the anterior portion of the tooth by an external and an internal cusp.

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[1] The dimensions of the premolars and the height of the mandibula are taken from Depéret's figures.

[2] Dimensions given by Gaillard, op. cit., pp. 61–62.

[3] Op. cit., pp. 62–63, pl. iii, fig. 4.

An isolated first upper molar probably belongs to the same species. Of known forms it can only be compared with m. 1 of *Mydaus* and the American Skunks. In general contour and some other particulars it resembles more closely *Mydaus*, but it is provided with a strong outer cingulum as in the molar of *Mephitis, Spilogale,* and *Conepatus,* and it is likewise more developed outside the antero-external cusp. The two outer cusps are wide apart as in all Melidæ; the internal range, composed of a large middle cusp with a smaller one on either side, agrees more with *Mydaus*, being parallel with the outer range, and not crescentic as in the American Skunks. The heel of the inner side is strongest on the postero-internal side of the tooth, without encroaching so much on the anterior side as in the Skunks.

	Measurements in mm.
From posterior part of m. 2 to anterior part of p. 1 ...	18·5
,, ,, m. 2 ,, ,, ...	4
,, ,, m. 1 ,, ,, ...	8·5
,, ,, p. 1 ,, ,, ...	6·5
Height of mandibula beneath m. 1	10
Length of upper molar	8·3
Breadth (posteriorly)	6·5

Schlosser has described[1] an isolated lower first molar, from the 'Pliocene' of Melchingen (Sigmaringen), under the name of *Promephitis Gaudryi.* This tooth closely resembles the corresponding tooth of the La Grive fossil, but the roots of the latter are not so weak, are less spreading, and there does not appear to be an anterior pit in Schlosser's specimen.

MUSTELIDÆ.

TROCHICTIS DEPERETI, sp. nov.

This new species is represented by an incomplete skull with associated left mandibular ramus (Brit. Mus. M. 5313). The posterior moiety of the cranium is preserved, of the anterior portion only part of the left maxillary with the four premolars and the canine. The mandible closely resembles the one of *T. Gaudryi,* Filh.—also represented in the La Grive collection—but is smaller and slenderer. Skull depressed and elongate, with large tympanic bullæ. The temporal ridges unite to form the sagittal ridge at about ten millimetres anterior to the occiput; the space between them has, on an average, a width of about seven millimetres.

Posterior upper premolar short, with strong internal cusp extending backward beyond the middle of the tooth. This tooth much resembles the p. 1 of *'Mustela' Filholi,* Dep., but is shorter still. P. 2 and p. 3 are two-rooted, in the main unicuspidate, with minute basal cusps at the anterior and posterior border; p. 4 minute, with posterior basal cusp.

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[1] *Geol. und Pal.* Abhh., v, 3, p. 32, pl. ii, figs. 14, 16 (1902).

	mm.
Length of upper p. 1	9
Transverse width of p. 1	6·5
Length of p. 2	6·5
,, p. 3	5
,, p. 4	2·5
Antero-posterior dimensions of C. at base	4
Dimensions of mandibular ramus:—	mm.
From anterior border of canine to posterior border of m. 2	44·5
,, ,, ,, of condyle	51
Length of m. 1	11·5
,, p. 1	7
,, p. 2	6
,, p. 3	5

TROCHICTIS PUSILLA, sp. nov.

A diminutive species of *Trochictis* is represented by a fragmentary left mandibular ramus with m. 1 and p. 1 in place and the alveolus of m. 2. M. 1 exhibits the characteristic very elongate talon of the genus, with a delicate crenulation of the internal upper margin of the talon, as in *T. taxodon*.

m. 1 = 6 mm.
p. 1 = 3 ,,
Height of mandibular ramus below m. 1 (int.), 3·5 mm.

IV.—THE AGE OF PYRENEAN GRANITE.

By P. W. STUART-MENTEATH, Assoc. R. S. Mines.

AN easy walk from Lourdes through Lésignan, Paréac, Orincles, Leyrisse, and Bénac, to the return station of Ossun, traverses the entire outcrop of the Upper Cretaceous Flysch, lying between the abrupt uprise of the Cenomanien limestone at Lourdes and the Danien that skirts the Tertiary plain towards Tarbes. The age of this Flysch is admitted; every objection regarding it has been successively abandoned; and its appearance, composition, and characteristic fucoids are as typical at Lourdes as at any point within fifty miles on either side. By insensible gradations it passes repeatedly from fresh marly shale with characteristic fucoids into micaceous schists that have been classed as Cambrian. Portions of a sandy character acquire vivid colouring and pass insensibly into a rock indistinguishable from decomposed granulite, while preserving their original bedding. Such changes occur on either side, or on the prolongation, of extensive lenticular intrusions of solid granite, which cross the indicated route between Paréac and Orincles and between Orincles, Visker, and Bénac. Across both altered and unaltered Flysch, large and small dykes of crushed schist, filled with angular blocks of granite, quartzite, etc., vertically intrude, and increase in number and size as the granite is approached. When these dykes appear they are accompanied by thin veins of granite cutting across the Flysch. These veins gradually increase in number, and insensibly blend into the solid granite already mentioned. At Leyrisse the passage is admirably exposed in fresh road-cuttings, both on approaching the granite from Orincles and on leaving it towards Bénac. The hypothetical assumption of islands of old rock in the Flysch has been proposed and subsequently abandoned by M. Carez as untenable; and the suggestion that some other name might be given to the granite is inconvenient, seeing that the rock in question has been recognised as granite during more than a century by every observer who has seen it.

My position in the matter differs from that of geologists who feel called upon to explain away what they suppose to be an exceptional anomaly. Since 1866, when I first studied these rocks during more than two months at Bagneres, I have traced the same phenomena throughout the Pyrenees. Around Leyrisse one sees merely a normal and usual feature of the Flysch, as I have studied that formation from St. Jean de Luz to the Corbieres. One sees completely exposed at Leyrisse a peculiar and complex mechanism of intrusion, eruption, and metamorphism, whose several features are unerringly recognisable in obscurer sections after the field-practice of many years. Its presence is verifiable in a single excursion at Leyrisse, but in some other cases has been only rendered certain by the patient researches and happy accidents of twenty years. Clearly conclusive sections and ample indications are now known to me along the entire Pyrenees. Along the hundred kilometres between Leyrisse and Iholdy the granitic penetrations of the Flysch are especially extensive and clear. Here rises the vast granitic intrusion between Iholdy and Cambo, which all recent textbooks assume to be of Archæan age. All observation, from Dufrénoy to my minutest mappings of the district, prove this granite to be as Cretaceous as its indubitable continuation to the east.

Between Suhescun and Iholdy, three miles to the south-east of the granite outcrop, the undisputed Flysch, mainly of white marl abounding in characteristic fucoids, forms a lofty ridge visibly seated on the same fossiliferous Cenomanien which similarly supports the Flysch elsewhere. Above this limestone, and in alternation with regular beds of white marl dotted with fucoids, one finds a series of great lenticles of angular breccia, mainly of ophite and quartzite, but including limestone, slate, and some fragments of granite and gneiss. Blocks of three to four yards in diameter of ophite and quartzite are conspicuous. These beds amount jointly to about 2,000 feet in thickness. They are clearly in every detail a repetition of the peculiar mechanism of Leyrisse. The ophitic character and composition are merely more prominent at this point; whereas at Leyrisse and to the west of Iholdy the granitic form predominates. Around Leyrisse the ophitic form of the same mechanism is frequently visible and soon predominant. At Iholdy the breccias pass into solid masses of ophite, and can in every detail be traced as eruptive intrusions traversing the Cenomanien limestone, and both traversing and feeding the sedimentary beds of the Flysch. No other explanation will fit the phenomena of Leyrisse and of the entire intermediate Flysch. I first discovered and classed the Pyrenean Flysch through familiarity with that of Greece, Italy, and Austria. Th. Fuchs classed that Flysch as of eruptive origin. Even in the Alpine Flysch the Taveyannaz Sandstone has been recognised as *eruptive, and as analogous* to Pyrenean ophites, by the only German *geologist who has* compared the two.

Besides the known and admitted Flysch of the Pyrenean outskirts, there is an interior Flysch which I have been gradually substituting for the Cambrian, Silurian, etc., of official maps. It faces that of Iholdy, as its corresponding southern outcrop, and presents 3,000 feet of angular blocks of every age, including fossiliferous Cenomanien; and it rests on a sheet of that Cenomanien, whose protruding points and edges have been affording me characteristic fossils for over twenty years. This conglomerate consists in great part of ophite blocks, and is crossed and penetrated by vast ophitic intrusions. Between Esterencuby and Eaux-Chaudes it is abundantly visible, and it is now admitted that the limestone on which it rests is not Cambrian but Upper Cretaceous, as I first mapped it in 1885.

Such radical admissions, along fifty miles and more, have led to the recognition that the central granite of the Pyrenees is post-Carboniferous and intrusive in synclines of Carboniferous rocks. The first of these synclines was proved by me with ample fossils in 1881. Its most certain features are figured in the map of Carez and Vasseur. The Survey geologists next represented my Carboniferous of Biriatou as pre-Cambrian, and my Trias of Vera as Carboniferous above Cambrian. In a map published in *Comptes Rendus* of June, 1894, I have shown the true relations. Their Carboniferous contains good specimens of *Radiolites foliaceus*, and their pre-Cambrian is the most typical Carboniferous in the Pyrenees. Similarly the Lourdes slates were classed as Silurian, *because* penetrated by granite, in spite of hundreds of Cretaceous Ammonites. The Cenomanien limestone of Vera, together with the Trias on which it rests, traverses the entire granite, as crystalline and graphitic marble, and emerges with Radiolites and Cretaceous corals towards San Sebastian. It is precisely analogous to the similar marble of the Cambo granite, which similarly emerges as Cenomanien. The presence of Muschelkalk, in which I have found the first Triassic fossils of the Pyrenees, is the only source of confusion to be avoided. But since 1885 sufficient fossils have enabled me to certify the presence of Cretaceous at Vera, Argelès, and elsewhere, along the synclines admittedly penetrated by granite. It must be consequently soon admitted that the granite is as little Carboniferous as Archæan. Another twenty years of useless controversy might be saved by impartial evidence on the spot. All the leading authors of the *charriage* theory have jointly exhibited their ingenuity at Biarritz in applying the resources of that theory to controvert the facts. They start from the sections of M. Carez in *Bull. Soc. Géol.* of 1896, and terminate with the final refutation of their illusions in the last published *Bulletin*. The relation of their methods to field-observation can be thus practically gauged, and it may be remarked that the clever educational manual of Commandant Barré quotes their Biarritz speculations as the most certain facts of Pyrenean geology.

ST. JEAN DE LUZ, *November* 5, 1903.

P.S.—Three recent visits to the "fundamental section" of the new and brilliant paradox of Gavarnie have convinced me that it consists of a bed of Devonian limestone with black schist both above and below. At the point selected, east of Gèdre, there is a small diagonal fracture along which a few inches of the black schist has been squeezed in. The fallen side shows intense and irregular metamorphism at a few yards distant, and on the neighbouring high road it rests admittedly on the granite. Similarly, around the Cambo granite, the admitted Flysch which passes insensibly to granite, and which is visibly traversed by granite and ophite veins, has been figured as unconformable overlaps or outliers. The author of the Gavarnie sections especially praises the observations of Jacquot, by which nearly all the Cretaceous of his own map was formerly classed as Cambrian. By reversing the process, he preserves the proof that all previous observation was wrong.

V. — OBSERVATIONS ON MR. S. S. BUCKMAN'S PAPER ON THE TOARCIAN OF BREDON HILL.

By Professor EDWARD HULL, LL.D., F.R.S.

THE above paper, read before the Geological Society on the 27th May last, having just reached my hands, with the discussion.[1] I trust you will allow me to make some observations thereon, not having been present on the occasion. As my name does not appear once throughout the paper it might at first sight be considered unnecessary, if not impertinent, for me to take any direct notice of its contents. I must therefore ask permission to state the reasons for this communication as briefly as may be, and they may be summed up in a single sentence—that, being responsible as the officer of the Survey who carried out the geological mapping of the Cotteswold Hills and of the outlying Bredon Hill, I cannot allow reflections on its accuracy to pass unanswered.

It was about the year 1853 or 1854 that my chiefs, Sir R. I. Murchison and Professor Ramsay, gave me instructions to undertake the geological survey of Sheet 44 of the Ordnance Survey, with the exception of the northern portion, which was entrusted to Mr. H. H. Howell. To the south of Sheet 44, the late Mr. Bristow was engaged in mapping the Oolites in the Bath district, and for some days I had the advantage of his practised guidance in learning the details of field-surveying amongst the Oolites. I accepted the commission with enthusiasm; few more choice districts for a young geologist were available, and throughout the period, about three years, during which I had the work in hand, I enjoyed the ready help and advice of my late valued friend Dr. Thomas Wright, F.R.S., of Cheltenham. It so happened that this was the very time during which Dr. Wright was engaged in his palæontological examination of the escarpment of the Cotteswold Hills, which led to his determination of the limits of the Liassic series on the one hand, and of the Oolitic on the other. Up to the time when I commenced my survey the yellow and variegated sands of Leckhampton and Crickley Hills, near Cheltenham, of Frocester Hill, and southwards, with the "Ammonite bed" at the top, were regarded as belonging to the Inferior Oolite. But when Dr. Wright discovered that the species of Ammonites, Nautili, and Belemnites were identical with those from the Upper Lias of Whitby, he found it impossible to resist the conclusion that the "Ammonite bed" (which he renamed the "Cephalopoda bed" in order to give it a wider signification), together with the underlying so-called "Inferior Oolite Sands," ought to be included in the Liassic rather than in the Oolitic series. Happily, about the same time D'Orbigny's work[1] made its appearance, wherein nearly all the Cephalopoda from the Ammonite bed are figured and described as "Toarcian" or Upper Lias forms, completely confirming Dr. Wright's conclusions, which were fully developed by the author in his elaborate paper "On the Palæontological and Stratigraphical Relations of the so-called Sands of the Inferior Oolite," read before the Geological Society in 1856.[2] Thus this important rectification of the succession of the Jurassic series of England was finally settled. Will it be believed that after the lapse of nearly half a century Mr. S. S. Buckman claims in his paper just published to have been the happy individual to whom the credit of so great a discovery ought to be awarded! For what does he say? It is this:—"Now that the faunal contents of the various sands are definitely known, the old, much-debated question, whether the sands are Liassic or Oolitic, may be considered as settled." The much-debated question *was* settled by Dr. Wright in 1856, and was accepted by the Geological Survey upon the publication of the memoir on the "Geology of the Country around Cheltenham" published in the year following. It is remarkable that throughout his paper, Mr. Buckman persists in calling the "Upper Lias Sands" of Wright the "Cotteswold Sands" and the "Midford Sands,"[3] the latter a name unknown to geologists in general, and adding another to the long list of fanciful names which some authors amuse themselves by inventing.

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[1] Q.J.G.S., vol. lix, p. 445.

Reverting to Mr. Buckman's paper, I am perplexed to find out where the author got hold of the idea, which he says "stands in the maps and textbooks," that the beds of the *bifrontis-falciferi*, which are only 10 feet thick at Wotton, had increased to 380 feet at Bredon Hill. Do the maps and textbooks referred to include those of the Geological Survey? If they do, I venture to assure Mr. Buckman that he is entirely mistaken. The 10 feet of clay at the base of the Upper Lias at Wotton is certainly not the representative of the entire Upper Lias at Bredon Hill. The idea is too absurd to be entertained for a moment, and, as Mr. Whitaker in the discussion points out, the Survey did not profess to theorize about fossil zones. The view which I myself held, and which was that, I believe, of my colleagues of the Survey, that the sands of Wotton with the clays below were representative in time of the Upper Lias of Bredon Hill; it was a case of different sediments brought from different directions —the clays from the north, and the sands from the south or south-east, and deposited over the floor of the then sea, mingling and inosculating towards the centre of the area. Similar changes are not uncommon.

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[1] "Prodrome de Paléontologie Stratigraphique," t. i, ii, iii.

[2] Journ. Geol. Soc., vol. xii, p. 292. I shall not forget the day, some time in 1855, on which Dr. Wright took me up with him to Frocester Hill to collect specimens from the Cephalopoda bed which are there so abundantly stored away in nature's museum. It was a revelation to me to see forms of Ammonites, which I knew to be Upper Liassic, come forth from the base of the Oolitic cliff.

[3] [The name "Midford Sands" was given, in 1871, by Professor Phillips to the sands which occur between the Upper Lias Clay and the Inferior Oolite. (Geol. [illegible])—EDIT. GEOL. MAG.]

It would be interesting to know who made the statement in the discussion that "the Geological Survey maps were only intended to be lithological charts of use to agriculturalists." I cannot find any such statement; but the author in replying to it throws out an idea which could only have been listened to with amazement, that for the use of agriculturalists the superficial deposits should have been mapped first, instead of last! Imagine Sheet 44 to have been published from the Geological Survey Office in the first instance for the use of the farmers, and only containing the superficial deposits, which do not cover more than a tenth of the whole area.

I regretted much to read the words of Mr. E. T. Newton, who was in the chair (p. 462), that a map executed fifty years ago naturally required "considerable modification." There are districts to which this statement might be applied, especially those where large mining works are being carried on, but I deny that it applies to the region of the Lias and Oolites. If the field work, the tracing of boundary-lines between formations or divisions, the insertion of faults and representations of dip, strike, and similar phenomena were accurately done in the first instance, no number of years would necessitate "considerable modification." Mr. Newton is an officer of the Geological Survey and recognised as able and distinguished, and the map Sheet 44 was the work, and is issued under the authority, of the same public department. Did he, before he made the above statement from the chair of the Geological Society, satisfy himself by personal examination that the geological map of the country around Cheltenham *does* require "considerable modification"? If he replies in the affirmative I have nothing more to say, but to ascertain the points to which he refers; if not, I should have supposed that a sense of *ésprit de corps* would have prevented such a statement.

I regret very much to have found it necessary to make these remarks, but a sense of justice to the memory of a former friend, and of duty towards that important branch of the public service in which I was proud to hold various positions through forty years, have called them forth.

VI.—Notes on the Witwatersrand Beds, Transvaal.[1]

By **Frederick H. Hatch**, Ph.D., F.G.S., M. Inst. C.E., formerly of the Geological Survey of England and Wales.

In discussing a paper by Mr. J. S. Curtis [2] on the Witwatersrand Gold Deposits, Mr. George Denny has raised the point that the slates or shales of the Witwatersrand, which especially characterise, but are not confined to, the Lower Witwatersrand Beds (Hospital Hill Series),[1] are not of sedimentary, but of igneous origin. He relies chiefly on the fact that he has observed in places that a so-called band of slate cuts across the bedding of the quartzites. I think we are all prepared to agree with him that, where he can point out that this occurs, the rock which traverses the bedded formation must be an igneous intrusion; but such cases are rare. In the vast majority of sections where the slates are exposed, they are found to occur truly bedded, and in conformable relation with the quartzites with which they are associated. It seems to me that, after all, this is in the main a petrological question, which can be easily settled by the examination of the rocks in question under the microscope. With this end in view I have examined a number of thin sections of these rocks, in all cases prepared from the cores of boreholes, on account of the difficulty of obtaining near the surface specimens sufficiently fresh and unweathered for microscopic examination; and I have selected geological horizons which are well known on the Witwatersrand. They are (1) the band of slates which occurs in the neighbourhood of the Bird Reef Series, and (2) the slates which occur in the footwall of the Main Reef itself, in both cases in the eastern portion of the Witwatersrand, as at Van Ryn and Geduld. In all I have examined thirty sections of slates.[2]

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[1] Abstract of a paper read before the South African Association of Engineers, Johannesburg.

[2] "*The Witwatersrand Ore* Deposits and their relation to the various Formations."

A surprising fact is at once revealed by the microscope, viz., that the slates, both in point of composition and structure, are closely related to the quartzites with which they are associated. We find that both quartzites and slates are composed of angular to subangular fragments of quartz imbedded in a microcrystalline to cryptocrystalline ground-mass. There are occasional flakes of a yellowish-green pleochroic mica, and iron pyrites occurs abundantly as an accessory constituent. Where the slates have a greenish tinge.

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[1] There is evidently some confusion existing among writers on Witwatersrand geology as to the use of the terms "Hospital Hill Series," "Hospital Hill Shales or Slates." Personally I have always used the expression "Hospital Hill Series" to include the whole of the slates and quartzites which occur in alternating belts between the outcrop of the Main Reef at Johannesburg and the granite north of the Houghton Estate ridge, or say between the City and Suburban Township and Orange Grove. In this sense the term is synonymous with "Lower Witwatersrand Beds," as used above. Others, no doubt, use the term "Hospital Hill Shales or Slates" to denote one particular belt of striped ferruginous shales which in Johannesburg is characteristically developed on the northern slope of Hospital Hill; for instance, in the Show Ground, Braamfontein. It is not so clear what is meant when the name "Hospital Hill Shales" is applied to ferruginous slates in other parts of the country (e.g. in the Heidelberg district), for although such beds belong no doubt to the Lower Witwatersrand Beds or Hospital Hill "Series," it is by no means certain that they can be correlated with that particular slate belt which occurs on the northern slope of Hospital Hill in Johannesburg; for banded ferruginous slates are not confined to one horizon in the Lower Witwatersrand Beds. Confusion would be avoided if writers would indicate whether they mean to imply the series as a whole, or a particular portion of it.

[2] I have to thank Mr. Holford, who has courteously placed at my disposal his collection of rock-sections from borehole cores from the Boksburg Gold Mines and Rand Klipfontein; Mr. D. Wilkinson, who has lent me sections from Cloverfield; and Mr. Dorffel, who has been kind enough to prepare me some sections from boreholes on Brakpan, Cloverfield, Welgedacht, Grootvlei, and other eastern farms.

this is due to the abundant presence of chlorite. The ground-mass is too minutely granular to allow of specific minerals being recognised, but it reacts under polarised light, and probably consists mainly of very finely comminuted quartz, together with a micaceous mineral, either muscovite or sericite, in minute blades. It is possible that there is also some admixture of clayey matter, kaolin or some similar mineral. No evidence of lath-shaped crystals or microlites of felspar, or augite granules, or indeed of any of the usual characteristics of igneous rocks is forthcoming. The differences observable under the microscope between quartzite and slate consist, firstly in the size of the quartz grains, and secondly in the relative proportion of quartz grains and ground-mass in the two rocks. In the quartzite, the quartz grains are fairly large and the ground-mass subordinate; in the slate, on the other hand, the quartz grains are small to minute, and the ground-mass predominant. The difference might be compared to that existing between sands and slimes, when speaking of tailings. Where a banded structure is observable in a hand-specimen of slate, under the microscope this is seen to be due solely to minute variations in texture and relative proportion of quartz granules, such as might be expected to occur under conditions of sedimentation from currents. It certainly is not 'flow-structure,' as this term is applied to igneous rocks. In short, the rocks I have examined are not igneous, but of detrital origin; or, in other words, they are true sediments of a quartzitic nature, and are correctly to be designated as slates on account of their minutely comminuted character, their banded or zonal variation due to sedimentation, and their slaty cleavage, which is of course a superimposed structure due to pressure, and may or may not be coincident with the bedding planes.

The presence of abundant iron pyrites in the slates is noteworthy, and may be due to the original sediments having contained carbonaceous matter, which subsequently acted as a reducing agent on sulphates dissolved in the circulating underground waters, sulphates being probably a common constituent of these waters.[1] The red oxides of iron, which characterise the slates when outcropping at the surface, must be products of decomposition of the pyrites. Can the decomposition of the pyrites also have given rise to specular iron and to magnetite, as these minerals also frequently occur in the surface rocks?

Another interesting feature, which I have only observed in the slates which occur in the neighbourhood of the Bird Reef (Cloverfield and Grootvlei), is the presence of rutile in innumerable minute hair-like needles or spicules, and only clearly definable by a high magnification. It is characterised by its high refractive index, straight extinction under crossed nicols, and the occasional presence of knee- and heart-shaped twins. The smallest needles appear as opaque lines on account of their needle character coupled with their high refractive index; but the larger prisms are transparent under a sufficiently high power, and then show a reddish-yellow colour. It will be interesting, and of considerable importance as a distinguishing character, should this rutile prove to be confined to the slates that occur *above* the Main Reef. There is a remarkable petrological resemblance between these slates and the phyllite of the Ardennes.[1] According to Renard, who has made a close study of the latter rocks, they are characterised by the presence of quartz, sericite, chlorite, rutile, and micaceous hematite, and these are just the minerals that characterise the Witwatersrand slates.

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[1] Cf. Van Hise, "Some Principles controlling the Deposition of Ores": Trans. *Amer. Inst. Min. Eng.*, vol. xxx (1901), p. 94.

Although, as I have shown above, the slates are not of igneous origin, I would like to point out that rocks of true igneous origin also occur in sheets or 'flows,' interbedded with the Witwatersrand Beds. For instance, boreholes that have been put down in the extreme Eastern Rand on the farms Geduld, Welgedacht, and Grootvlei, have all intersected a sheet of amygdaloidal diabase varying in thickness from 100 to 300 feet, and situated some little distance above the Modderfontein Series. This, however, is quite different in character from the slates. Although very fine-grained or aphanitic in the hand-specimen, it can at once be distinguished under the microscope by the presence of lath-shaped felspar crystals. These are turbid through kaolinisation, and what was probably augite is now only represented by patches of chlorite. The rock therefore shows signs of considerable decomposition, which is remarkable when we consider that the specimens examined come from a great depth (2,600 feet in the Grootvlei borehole). It is, however, clearly recognisable as a diabase. Its chief characteristic in the hand-specimen is the presence of almond-shaped infilled vesicles of calcite, chlorite, and other secondary minerals. That this rock should be so decomposed at such a considerable depth below the surface bears witness to the power of circulating underground waters in effecting mineralogical changes. With regard to the main contention of Mr. Curtis's paper, viz., that the auriferous contents of the banket beds were introduced by the agency of underground waters subsequently to the deposition of the conglomerate beds, this has always been my view;[2] but it is scarcely correct to designate this as 'lateral secretion,' as Mr. Curtis does. Sandberger introduced this term in 1877 to denote the process by which the metallic contents of mineral veins had been derived from their enclosing 'country' or wall rocks.[3] It is true that in America the term has been extended to include derivation from subjacent rocks, and in this sense no doubt Mr. Curtis meant to use it.

An important fact to be borne in mind when discussing the origin of the gold in the banket is the close association of the gold with sulphide of iron in the form of pyrites. It seems to me that if it can be shown that the pyrites in the conglomerates is of secondary origin, it must also be admitted that at least the gold which is locked up in the pyrites crystals could not have been there before the pyrites itself was formed. Rickard[1] has explained the origin of the gold in the auriferous sulphide reefs of Australasia and Colorado as being due to the presence of organic matter. It would be interesting in this connection to investigate the occurrence of a black mineral, resembling and generally supposed to be graphite, in the Rietfontein and Buffelsdoorn Mines. It has been suggested above that the presence of pyrites in the slates is perhaps due to carbonaceous matter being present in the original mud from which they were formed. The same mode of origin might be applied to the pyrites in the banket, and would also account for the precipitation of the gold in the metallic state.[2] I admit that it is difficult to understand why other conglomerate beds (Kimberley Series, Bird Reef Series, etc.), which otherwise greatly resemble the auriferous bankets, and also contain pyrites, should be poor in gold; but the conditions governing the circulation of underground waters, and the nature of the precipitating agencies likely to have been contained in the beds, are very little known to us, and there are possibilities of infinite variation in these conditions.

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[1] Geol. Mag., 1883, pp. 322–324 (abstract).

[2] Quart. Journ. Geol. Soc., vol. liv (1898), p. 81.

[3] Sandberger, "Zur Theorie der Bildung der Erzgänge Berg. u. Hüttenm.": *Zeitung*, xxxvi, Nos. 44–45.

I have elsewhere[3] dwelt on the large amount of secondarily deposited silica which the matrix of the conglomerates contains, partly in the form of minute crystalline quartz, partly of opaline nature. It is this secondary quartz which knits the originally loosely compacted mass into a hard and almost glassy mass, almost approaching vein quartz in texture, in which the margins of the pebbles are almost obliterated, the rock breaking across matrix and pebbles indiscriminately. This silica must have been deposited from water, and is additional evidence in favour of hydrothermal agencies as a factor in the origin of our gold-reefs.

VII.—NOTES ON TWO POINTS IN AFRICAN GEOLOGY.

By F. P. MENNELL, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

MR. J. E. S. MOORE'S interesting work on the "Tanganyika Problem," reviewed on p. 418 of the September number of the GEOLOGICAL MAGAZINE, raises some interesting points in connection with African geology, though, as your reviewer rightly remarks, we are indebted to Mr. Moore rather for a statement of the problem "than for proposing an adequate solution of it." At the same time it must be admitted that Mr. Moore's general geological conclusions appear to me, as a worker in Africa, much more in accordance with the facts as I see them in the course of my every-day life, than the hypotheses of certain eminent geologists who have preceded him. There is always a great disposition on the part of visitors to a little-known country to theorise, without having had time or opportunity for making those accurate and detailed observations which are essential if deductions are to be made which will stand the test of time. And the worst of it is, 'authority' has so much weight that local workers have the utmost difficulty in removing false impressions which may thus be caused. Two points to which I may refer are the "antiquity of the African continent" and the so-called 'Rift-valleys.' Now whatever may be the antiquity of Africa as a land surface, facts are constantly coming to light which throw great doubt on its having the stability attributed to it. Fossils of Jurassic and Cretaceous age are known from numerous places, and though these are chiefly confined to the coastal fringe, fresh discoveries are frequently increasing the area, such as the recent one far inland in the Sahara. Further, though the absence of marine fossils—or, rather, of any fossils at all—from the sandstones which cover immense areas in Tropical Africa may be held to denote a lacustrine origin for the beds, it is quite possible, as Mr. Moore seems to take for granted, that they may be marine. They are largely red sandstones with intercalated lavas (basalt, etc.), and extend from the edge of the African plateau on the east to its western limit, and from the Limpopo to the Equator or near it. These beds are involved in the mountain-building on the south-east border of Rhodesia, and it thus appears possible that no mountain barrier originally existed along the east coast. Indeed, I believe the beds reach down into the low country near Sofala, where Cretaceous fossils occur. These red sandstones are particularly well developed in the Congo basin and the Zambesi basin. Mr. Moore calls them[1] the "Old African Sandstones," and considers that they underlie "Drummond's Beds." There must be some mistake here, as the latter no doubt correspond to the Permian coal-beds of Rhodesia, while the sandstones are what I have tentatively classed as of Tertiary age,[2] and extend almost continuously through Rhodesia from Lake Tanganyika to Bulawayo.

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[1] T. A. Rickard, "The Origin of the Gold-bearing Quartz of Bendigo Reefs": Trans. Amer. Inst., vol. xxii (1893), pp. 314–315. "The Enterprise Mine, Rico, Colorado": Trans. Amer. Inst., vol. xxvi (1897), pp. 977–979.

[2] The possibility that water-worn pellets of iron pyrites (referred to by Mr. Denny) might also occur is not excluded; yet it may be that these pellets are not water-worn, but are of concretionary origin, in which case they would probably show a radial fibrous structure.

[3] *Quart. Journ. Geol. Soc.*, vol. liv (1898), pp. 80 and 81.

But, granted that these beds are non-marine, the freedom of the continent from extensive earth-movements does not rest on any sounder basis. The beds are largely involved in orogenic movements, not only round Lake Tanganyika, but also in Southern Rhodesia, and frequently dip at considerable angles. The great volcanic activity that they evidence is another point against stability. But the strongest argument is the insignificant amount of denudation accomplished since the great plateau has been raised to its present elevation of about a mile above sea-level. We have gently undulating or flat country with deeply scored valleys; the streams are as yet simply torrents employed in deepening their beds. They have not begun to affect the general level of the country, while falls and rapids are of frequent occurrence even in the great rivers, an impossible state of affairs in the absence of earth-movements for long-continued periods.

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[1] "The Tanganyika Problem," p. 65.

[2] Ann. Rep. Rhodesia Museum, p. 9.

The condition of things just remarked upon brings us naturally to the second point—'rift-valleys,' which have been brought forward to explain the features so obviously due to denudation having been confined to the stream-beds, with minor complications in the way of lake deposits and uplift or subsidence. It is the latter details to which the theory is primarily due, as it never seems to have occurred to anybody that slight movements of elevation or depression may cause deposition of sediments in a deep valley. The Zambesi due north of Bulawayo flows in a broad valley over a floor of Tertiary sandstones, etc., about 1,500 feet above sea-level, with Archæan schists and granite rising into hills over 4,000 feet high within a few miles. But nearer its mouth it crosses an axis of elevation which has given rise to the Shire highlands and the mountains of the Rhodesian border, as well as the Drakensberg and other ranges which have forced the rivers further south, like the Orange, to flow from close to the east coast right across the continent to the western sea. Is it not reasonable, therefore, to suppose that the Zambesi, after eroding a deep valley, was forced by elevation near the coast to deposit its sediments in a great lake which at first covered a wide area of country? Erosion would to some extent keep pace with denudation, and as the uplift was not sufficient at its maximum to reverse the course of the river, when it ceased the lake would first be confined to the original wide valley of erosion, and finally the river, as it is doing to-day, would reduce the level of its bed until it made a new one in the sediments it had itself previously deposited.[1]

No one would now argue that the Colorado cañons or the valleys of the Blue Mountains are due to anything but normal erosion; why, then, should our unfortunate African rivers be still given over to the catastrophist?

VIII.—RECENT BRECCIAS IN BOLIVIA.

By JOHN WILLIAM EVANS, Ll.B., D.Sc., F.G.S.

IN February of last year Professor Bonney read an instructive paper before the Geological Society,[2] in which he enumerated and briefly described a number of the principal breccias found in the geological series. He also gave a short description of some of the best known recent breccias—the stone rivers of the Falkland Islands and the angular detritus that fringes the foot of the hillsides in Persia, Central Asia, and Northern Hindustan. In conclusion, he expressed his opinion that most of the ancient breccias referred to in his paper indicated "a climate, arid, liable to extremes of temperature, with cold winters. The precipitation probably was connected with this season, and took the form of snow." He thought, however, that in some cases "hot summers and occasional torrential rainfalls" might produce the same effects.

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[1] In the case of undoubtedly marine sediments like those of Egypt, rapid submergence and subsequent re-elevation would account for the phenomena observed.

[2] Q.J.G.S., lviii, *pp. 185–203*; see also a paper by Professor Blake in the same *volume, p. 290.*

I have recently had an opportunity of examining an extensive breccia at the foot of the Andes and margin of the Amazonian plain, which is still in process of formation under somewhat different conditions.

In north-eastern Bolivia the Andes consist of numerous parallel ranges trending north-west and south-east. At the point where the river Beni enters the great forest plain the outer or north-eastern chain is that to which I have referred[1] as the Bala-Susi mountains. The highest summits rise to about 5,000 feet above the sea, but some of the saddles do not exceed 2,000 or 2,500 feet in altitude.

The lower slopes are clothed with trees, and from their foot, at an altitude of 650 to 1,500 feet, commences a gentle incline. This is covered with thick forest, and extends outwards for two or three miles, till, at a height of from 570 to 700 feet, it reaches the plain which stretches with scarcely a break to the mouth of the Amazon.

The mountains are composed mainly of sandstone, and the incline to which I have referred is largely made up of a breccia of the same rock, while the lower ground beyond is a tract of alluvial sand and mud.

The climate is moderately warm, the highest maximum at the foot of the mountains in the months of December and January, 1901-2, being 92·5° F., the average maximum 85°, the lowest minimum 63·2°, and the average minimum 71·5°. The average pressure of aqueous vapour was ·76″. The total rainfall in the year is probably about 90 inches, of which the greater part falls from October to April, not continuously, but mainly in torrential showers brought by south-eastern storms. There is no season completely free from rain.

The rivers that flow from the mountains to the plain rise in a lofty longitudinal valley, break through the north-eastern hills at intervals in narrow gorges, and after a steep descent reach the inclined surface of which I have spoken. I followed the Rio de Tumupasa through almost all its course; its length from its origin to the point where it leaves the mountains is rather more than three miles, during which it descends over 1,200 feet. Its bed then forms a broad road through the forest, with an irregular surface of fragments of rock of all sizes, from coarse sand-grains to angular blocks several feet in diameter. There are few rounded pebbles, though the edges of the fragments are in many cases blunted by friction.

Through this rocky tract flows at ordinary times only a small stream, and even that is found to disappear under the débris as the river is descended, leaving the broad band of rocks to continue its way down the almost imperceptible incline till, at a distance of two miles from the foot of the hills, it reaches the low-lying plain. Here it spreads out and divides into short blunt branches, and thus abruptly comes to an end.

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[1] Geographical Journal, xxii, p. 601 (1903).

Beyond is nothing, except the forest with its smooth level floor of vegetable mould covered with undergrowth, scarcely a hollow to represent the river-bed.[1] Indeed, in the lower portion of the course of the stone river the fragments are in some places piled up higher than the adjoining forest soil.

The other rivers are similar in character.[2] In some cases the width of the bed of rock-fragments is much greater. Occasionally it may divide into branches, and these may again unite so as to surround an island of forest. The larger streams do not disappear, but continue beyond the end of the breccia as ordinary rivers.

In times of heavy rainfall the water from the mountains comes pouring out through the gorges, hurrying along with it the rocks that have fallen into the river-channels. When the flood reaches the forest slope, the fragments are carried on for a distance that depends on their size and the strength of the current. Rocks at least a foot in diameter may be deposited even near the end of the river of stones, for the forest and undergrowth usually keep the solid material as well as a great part of the water from diverging to one side or the other, although there may be no banks to keep them in.

When the plain, already flooded by the rains, is reached, the river spreads out, loses its current and identity as if it had entered a sea or lake, and leaves the last of its burden of sandstone blocks behind.

Much of the transport, especially of the larger fragments, takes place at the time of exceptionally great floods, and it is probable that some blocks may lie in the gorges for years till an abnormal downpour gives the rivers sufficient force to sweep them away.

After a river-bed has been raised by successive accumulations of stone fragments, the time comes when a strong flood finds it easier to take a new course in spite of the obstacles presented by the forest. Usually the river extends its bed on one side, destroying the trees that stand in the way, and leaving part of its former course to be overgrown by vegetation, or it may take an entirely different path and gradually send out a new river of stones into the forest.

By changing their courses in this way from side to side, the rivers slowly raise the level of the forest slope, with the assistance, near the foot of the mountains, of the smaller streams that flow off the side of the outer hills.

At some points the rivers cut through former accumulations of breccia, so that there is an opportunity of examining its structure. This appears to be identical with that of the material now being laid down. As would be expected, there is not much trace of stratification, though there is a tendency for the fragments to lie with their longer axes horizontal. There are few remains of the forest, for wood enclosed among the fragments and exposed to the action of air and water, and of insects and other organisms gaining access to it through the interstices of the breccia, would soon disappear.

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[1] I was told that further to the north-east at a lower level—for even the plain has a slight inclination—the stream reappears at the surface.

[2] On the road from San Buena Ventura to Tumupasa, which runs through the forest for about forty miles parallel to the mountains, I passed nineteen stone rivers, of which two were dry, besides numerous small forest streams without stones.

With the limited time and opportunities which I had, I was not able to form an exact idea of the extent of the formation. Its width is that of the slope to which I have referred—from two to three miles, perhaps more in places. The thickness must vary from point to point; it may sometimes—with interstratified beds of sand—amount to as much as five or six hundred feet. The length near Tumupasa will be equal to that of the Bala-Susi mountains, nearly a hundred miles, but breccias must be forming under exactly similar conditions in many other places at the foot of the outer ranges of the Eastern Andes.

It is sufficient for the present if I have shown that extensive breccia formations, in many respects similar to those found among the European strata, are now being accumulated in a thickly wooded, well-watered country, with a moderately warm and nearly uniform climate.

IX.—NOTE ON *VESTINAUTILUS CRASSIMARGINATUS*, A. H. Foord.

By G. C. CRICK, Assoc.R.S.M., F.G.S., of the British Museum (Natural History).

THE species *Vestinautilus crassimarginatus* was founded in 1900 by Dr. A. H. Foord[1] upon some (apparently three) specimens from the Carboniferous Limestone of Little Island, near Cork. It was described as follows:—

"Shell discoid, with slowly increasing whorls, all exposed in a deep umbilical cavity having a large central vacuity. The whorls are digonous in section, the peripheral area making a broad flattish arch; the sides, which form the steeply descending umbilicus, diverge at an obtuse angle from the margin of the latter; they are somewhat inflated in the lower half, and slightly concave in the upper, resembling those of *Vest. cariniferus*[2] in this respect. The contact or inclusion of the whorls is very slight, and, so far as can be made out from a section, there is no perceptible zone of impression. Owing to this slight amount of overlapping of the whorls, part of the peripheral area is exposed in the umbilicus, the inner whorls thus making a deep channel where they abut against those that embrace them. The umbilical border is marked by a strong, rounded rim, which becomes very prominent in the adult and senile stages.

"In the young shell the rim is about as prominent as it is in the adult of *Vest. cariniferus*, J. de C. Sow. [sp.], and other allied species. The conical apex of the young shell is ornamented with a series of close-set, fine, longitudinal ridges, and these are crossed by minute transverse striæ, which, cutting the former, impart a beautifully crenulated appearance to this part of the shell as seen under the lens. After the first whorl is passed the spiral lines begin to widen, and those of the lower half of the whorl entirely disappear, leaving five ridges, the two lower ones being very faint, till finally they all become obsolete, leaving only the transverse lines. These are regularly arranged and very numerous, their distance apart in the adult shell being almost exactly 1 mm. From the appearance presented by one of the specimens it would seem that they imbricate, but this is not very distinctly seen. They form upon the peripheral area a very distinct and deep, backwardly-directed sinus, indicating the presence of the hyponomic sinus of the aperture. On each side of the peripheral area there are three or four faint ridges in the young shell, but before the second whorl has been reached they have entirely disappeared. In a large individual in the senile stage of growth obscure folds and tubercles are developed upon the peripheral area and in one or two places upon its margin, but these are not sufficiently prominent to alter the general features of the shell.

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[1] Monograph on the Carboniferous Cephalopoda of Ireland (Pal. Soc.), pt. iii (1900), p. 79, pl. xxiii, figs. *5a-c*.

[2] *Nautilus cariniferus*, J. de C. Sowerby, Min. Con., vol. v, p. 130 (1824), *pl.* ccccLxxxii, fig. 3, excl. fig. 4. See also A. H. Foord, Mon. Carb. Ceph. Ireland *(Pal. Soc.)*, pt. iii (1900), p. 82, pl. xxiii, figs. 1-3; pl. xxvii, figs. 2a, b.

"The septation is not known . . . .

"The siphuncle is about twice its own diameter from the peripheral margin.

"The body-chamber is imperfect in the specimen in which it is seen . . . .

"The test is rather thick, especially upon the umbilical border, where it forms the thickened rim . . . ."

In his remarks on the species the author says: "The question of the generic affinities of this shell is a difficult one to settle in the absence of a sufficient number of specimens wherewith to study the stages of growth from the very young to the old shell, and their modifications. . . . It is unfortunate that the septation is not to be got at, as this would have aided very much in the determination of the affinities of the fossil."

The dimensions given of the largest specimen (which was elliptical) known to the author are:—greatest diameter, 127 mm.; smallest diameter, 102 mm.; height, from centre of area of inclusion to centre of ventral area, 24 mm.; width, from the summit of one umbilical rim to the summit of the other, 44 mm.

Though exhibiting some differences from the figured example, there is in the British Museum a specimen (No. C. 8861) which in my opinion is referable to this species; and which, if correctly identified, adds to our knowledge of the species by revealing to some extent the form of the septal sutures; unfortunately, the locality whence the specimen was obtained has not been recorded.

The latter half of the outer whorl of the fossil is very slightly crushed, but the specimen is not otherwise distorted. The fossil is 85 mm. in diameter; it is entirely septate; the body-chamber is wanting, and a portion of the inner whorls is either absent or obscured by the matrix which covers the central vacuity; the outer whorl and nearly a half of the penultimate whorl are clearly shown, the rest of the latter being only faintly indicated in section in the matrix; then follows a length of about 10 mm. of the antepenultimate whorl, whilst the rest of the inner whorls are entirely covered by matrix. The lateral aspect of the shell agrees very well with that given by Dr. Foord (*op. cit.*, pl. xxii, fig. 5*a*), allowance being made for the elliptical form of the figured example. The fossil shows the crenulated ornamentation of the young shell; also the subsequent spiral ridges occurring on both the lateral and the peripheral sides of the prominent umbilical margin, and which, gradually disappearing, leave only fine, well-marked transverse striæ; on the greater part of the side of the whorl these striæ are a little reclined[1]; rising with a backwardly-directed curve on to the umbilical margin, they cross the peripheral area with a very distinct and deep, backwardly-directed sinus, indicating the presence of the hyponomic sinus[2] of the aperture. On the outer whorl of the specimen this sinus is somewhat deeper and narrower than Dr. Foord's figure (fig. 5*b*) represents, but this seems to be due in part, but only in part, to the fact that the latter half of the outer whorl has been somewhat compressed laterally, sufficient, however, to force outwards the central portion of the peripheral area and eventually to fracture it. Consequently the median portion of the periphery of this part of the fossil is much more convex than is represented even in the lower part of Dr. Foord's figure (fig. 5*b*),[3] in fact the two sides of the peripheral area are inclined to each other at an angle of rather more than 100°; the peripheral area of the earlier and uncompressed part of the whorl is, however, relatively less convex. Owing to the compression already mentioned, the transverse section of the anterior end of the outer whorl of the specimen is almost pentagonal in outline, and the proportion of its dorso-ventral diameter (or height) to its transverse (or width) is greater than shown in Dr. Foord's figure (fig. 5*c*). the height, from the centre of the area of inclusion to the centre of the peripheral area, being 35 mm., and the width, from the summit of one umbilical rim to the summit of the other, 41·5 mm., the corresponding dimensions given by Dr. Foord, in an example 127 mm. in diameter, being 24 mm. and 44 mm. respectively. This proportion is rendered greater than it would naturally be by the fact that the test is imperfect on the umbilical rim on one side and entirely wanting on the other. At the anterior end of the specimen the siphuncle is seen, but owing to the compression of the whorl it is not quite in the median line; it is nearly 5 mm. in diameter, its outer surface being 10 mm. below the centre of the periphery, this being the position assigned to it by Dr. Foord; the 'zone of mpression,'[1] though shallow, is here well marked and about 13·5 mm. vide, but this may have been much narrower or even have entirely lisappeared on the body-chamber, so that the transverse section of he body-chamber may have been more nearly digonal. Fortunately n the present specimen a few of the septa are visible, or at least artially visible; near the anterior end of the specimen they are bout 6·0 mm. apart; they are, however, best displayed at about the ommencement of the last third of the outer whorl, i.e. where he specimen is 69 mm. in diameter; here they are seen on portion of the peripheral area and on a part also of the side of he whorl; on the lateral area they form a very slight backwardly-lirected curve, and, crossing the umbilical rim, traverse the peripheral rea in almost a straight line, or with only a very feeble backwardly-lirected curve; on the periphery they are about 7·0 mm. apart. So far as can be seen, the form of the septation closely resembles hat of *Vestinautilus pinguis* as figured by Dr. Foord,[2] but the hambers are a little shallower than shown in that figure. Notwith-tanding the characters which differentiate this specimen from Foord's figured example, viz., the greater convexity of the peripheral area, he narrower and deeper hyponomic sinus, and the relatively greater height of the whorl in proportion to its width, there can be no doubt that the two forms are very closely allied and most probably specifically identical. In referring his species to the genus *Vestinautilus*, Dr. Foord seems, therefore, to be correct, the form of the septal sutures supporting that conclusion.

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[1] In the coiled shell of a Cephalopod the ribs or striæ are said to be 'direct' when their direction coincides with the radius; 'inclined' when they are forwardly-disposed in relation to a radius; and 'reclined' when they are backwardly-directed in relation to the same line.

[2] The sinus of the aperture at the median part of the peripheral area or venter indicating the position of the funnel or hyponome.

[3] It is to be noted also that the periphery in Dr. Foord's diagrammatic transverse section of the whorl (fig. 5c) is much less convex than it is represented at either the lower or the upper part of the front view of the fossil depicted in his fig. 5b.

NOTICES OF MEMOIRS, ETC.

I.—Floras of the Past: their Composition and Distribution. By A. C. Seward, F.R.S., Fellow and Tutor of Emmanuel College, Lecturer on Botany in the University of Cambridge.

(*Continued from the November Number, p.* 512.)

THE geographical distribution of plants of approximately Rhætic age is shown in the following table on p. 557, which demonstrates an almost worldwide range of a vegetation of uniform character. The character of the plant-world is entirely different from that which we have described in speaking of the Palæozoic floras. Gymnosperms have ousted Vascular Cryptogams from their position of superiority; ferns, indeed, are still very abundant, but they have undergone many and striking changes, notably in the much smaller representation of the Marattiaceæ. The Palæozoic Lycopods and Calamites have gone, and in their place we have a wealth of Cycadean and Coniferous types. As we ascend to the Jurassic plant-beds the change in the vegetation is comparatively slight, and the same persistence of a well-marked type of vegetation extends into the Wealden period. It is a remarkable fact that after the Palæozoic floras had been replaced by those of the Mesozoic era, the vegetation maintained a striking uniformity of character, from the close of the Triassic up to the dawn of the Cretaceous era.

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[1] The 'zone of impression' or 'impressed zone' is the zone which is in contact with, and impressed by, the peripheral area of the preceding whorl.

[2] *Op. jam cit., pl.* xxv, *fig.* 3*a.*

MESOZOIC FLORAS.—It may be of interest to glance at some of the leading types of Mesozoic floras with a view to comparing them with their modern representatives. We are so familiar with the present position of the flowering plants in the vegetation of the world, that it is difficult for us to form a conception of a state of things in the history of the plant-kingdom in which Angiosperms had no part.

A. *Conifers.*—How may we describe the characteristic features of Rhætic and Jurassic floras? Gymnosperms, so far as we know, marked the highest level of plant-evolution. Conifers were abundant, but the majority were not members of that group to which the best known and most widely distributed modern forms belong.

A comparison of fossil and recent conifers is rendered difficult by the lack of satisfactory evidence as to the systematic position of many of the commoner types met with in Mesozoic rocks. There are, however, certain broad generalisations which we are justified in making; such genera as the Pines, Firs, Larches, and other members of the Abietineæ appear to have occupied a subordinate position during the Triassic and Jurassic eras; it is among the relics of Wealden and Lower Cretaceous floras that cones and vegetative shoots like those of recent Pines occur for the first time in a position of importance. There are several Mesozoic Conifers, to which such artificial designations as *Pagiophyllum*, *Brachyphyllum*, and others have been assigned, which cannot be referred with certainty to a particular section of the Coniferæ; these forms, however, exhibit distinct indications of a close relationship with the Araucarieæ, represented in modern floras by *Araucaria* and *Agathis*. The abundance of cones in Jurassic strata showing the characteristic features of those of recent species of *Araucaria* affords trustworthy evidence as to the antiquity of the Araucarieæ, and demonstrates their wide geographical distribution during the Mesozoic era. Additional confirmation of the important status of this section of the Coniferæ is afforded by the abundance of petrified wood exhibiting Araucarian features, in both Jurassic and Wealden rocks. There is good reason to believe that the well-known Whitby jet was formed by the alteration of blocks of Araucarian wood drifted from forest-clad slopes overlooking a Jurassic estuary that occupied the site of the moors and headlands of North-East Yorkshire.

B. *Cycads.*—One of the most striking features of the Mesozoic vegetation is the abundance and wide distribution of Cycadean plants. To-day the Cycads or Sago-Palms are represented by ten genera and about eighty species; they are plants which occupy a subordinate position in modern floras, and occur for the most part as solitary types in tropical latitudes, never growing together in sufficiently large numbers to constitute a dominant feature in the

I. RHÆTIC FLORAS.—GEOGRAPHICAL DISTRIBUTION OF A FEW CHARACTERISTIC TYPES.

Characteristic Types.	Arctic.						N. Temperate.			N. Sub-tropical.				Tropical.			S. Sub-tropical			S. Temperate.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
EQUISETALES																						
Equisetites Muensteri *Equisetites arenaceus*		x					x	x		x	x					x						
Schizoneura								x			x	x				x		x				
Phyllotheca											x								x		x	
FILICALES																						
Clathropteris *Dictyophyllum*							x	x			x	x				x			x			
Laccopteris								x											x			
Todites		x					x	x			x	x				x			x		x	
Tæniopteris							x	x		x	x					x		x	x			
Thinnfeldia								x								x	x	x	x		x	
Sagenopteris							x	x											x		x	
CYCADOPHYTA																						
Cycadites							x	x								x						
Podozamites		x					x	x			x					x						
Otozamites								x		x	x			x		x						
Anomozamites								x			x			x		x						
Pterophyllum		x					x	x			x			x		x			x		x	
GINKGOALES																						
Baiera *Ginkgo*		x					x	x			x							x	x		x	

vegetation. Before the end of the Palæozoic era there existed plants bearing pinnate fronds similar to those of recent species of Cycadaceæ, and in succeeding ages the group rapidly increased in number and variety till, in the Jurassic and the early Cretaceous periods, the Cycads asserted their superiority as the leading type of vegetation. The majority of Mesozoic Cycadean fronds are assigned to artificial or form-genera as an indication of our ignorance of their reproductive organs, or of the anatomical structure of their stems. As Professor Nathorst has recently suggested, it is convenient to speak of these Cycadean remains as belonging to the group Cycadophyta. On the other hand, we find numerous petrified stems bearing well-preserved reproductive organs which enable us to compare the extinct with the existing species. We are in possession of enough facts to justify the statement that the majority of Mesozoic Cycads bore reproductive organs which differed in important morphological characters from those of existing forms. The Bennettiteæ, originally founded on a petrified stem discovered more than fifty years ago in the Isle of Wight, possessed a thick stem, clothed with an armour of persistent leaf-bases and bearing a crown of pinnate fronds, as in most modern Cycads; but their flowers, which were borne on lateral shoots, were more highly specialised than those of the true Cycads. While most of the Mesozoic Cycads were no doubt members of the Bennettiteæ, others appear to have possessed reproductive organs like those of recent species. The Bennettiteæ belong to that vast army of plants that succumbed in the struggle for existence æons before the dawn of the Recent period.

The wealth of Cycadean vegetation during the latter part of the Jurassic and the earlier stages of the Cretaceous periods is admirably illustrated by the discovery in the Black Hills of North America and in other districts of the United States of hundreds of silicified trunks of Cycadean plants. The investigations of Mr. Wieland, of Yale, who has been engaged for some time on the examination of this rich material, have already revealed the fact that in some of the Bennettiteæ the male and female organs were borne in a single flower, the female portion having a structure identical with that previously described from European stems, while the male flowers bear a close resemblance to the fertile fronds of a Marattiaceous fern.

C. *Ginkgoales.*—Before leaving the Gymnosperms a word must be said about another section—the Ginkgoales—represented by the Maidenhair-tree of China and Japan. *Ginkgo* (or *Salisburia*) *biloba* has almost, if not quite, ceased to exist in an absolutely wild state, but as a cultivated tree it has now become familiar both in America and Europe. The abundance of fossil leaves, like those of *Ginkgo biloba*, and of other slightly different forms referred to the genus *Baiera*, associated not infrequently with remains of male and female flowers, demonstrates the ubiquitous character of the Ginkgoales during the Rhætic, Jurassic, and Wealden periods. In the Jurassic shales of the Yorkshire coast, *Ginkgo* and *Baiera* leaves occur in plenty, some of them practically identical with those of the

II. WEALDEN FLORAS: GEOGRAPHICAL DISTRIBUTION OF CHARACTERISTIC TYPES.

Characteristic Types.	Arctic.						N. Temperate.			N. Sub-tropical.				Tropical.			S.Sub-tropical			S. Temperate.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
EQUISETALES																						
Equisetites							x	x					x									
FILICALES																						
Onychiopsis		x					x	x					x					x	x			
Matonidium							x	x														
Cladophlebis		x					x	x					x					x	x			
Sphenopteris							x	x										x				x
Weichselia							x	x					x									
Tæniopteris		x		x			x	x										x				
Laccopteris								x														
Gleichenites			x					x														
GINKGOALES																						
Baiera *Ginkgo*		x		x	x		x	x														
CONIFERALES																						
Sphenolepidium		x					x	x														
Araucarites							x	x														
Pinites			x					x														
CYCADOPHYTA																						
Nilssonia								x					x					x				
Otozamites		x						x														
Zamites							x	x					x					x				
Bennettites							x	x														

existing species. The abundance of fossil Ginkgoales in other parts of the world—in Australia, South Africa, South America, China, Japan, North America, Greenland, Franz Josef's Land, Siberia, and throughout Europe—demonstrates the former vigour of this class of plants, of which but one member survives. This type of Gymnosperm is distinctly foreshadowed in the Palæozoic vegetation, and as recently as the Eocene period a species of *Ginkgo*, indistinguishable in the form of its leaves from the living Maidenhair-tree, flourished in Western Scotland.

D. *Ferns.*—Although many of the Mesozoic ferns are preserved only in the form of sterile fronds and are of little botanical interest, several examples of fertile leaves are known which it is possible to compare with modern types. The Polypodiaceæ, representing the dominant family of recent ferns, are met with in nearly all parts of the world and possess the attributes of a group of plants at the zenith of its prosperity. We may confidently state that so far as the somewhat meagre evidence allows us to form an opinion, this family occupied a subordinate position in the composition of Mesozoic floras. Polypodiaceous sporangia have been met with in Palæozoic rocks, and their existence during the Mesozoic period is not merely a justifiable assumption, but is demonstrated by the occurrence of undoubted species of Polypodiaceæ. It seems clear, however, that this family did not attain to a position of importance until the Mesozoic vegetation gave place to that which characterises the present period. The Osmundaceæ are now represented by five species of *Todea* and four of *Osmunda*. They flourished over the greater part of Europe during the Rhætic and Jurassic periods; their remains have been recorded from England, Germany, Scandinavia, Russia, Poland, Siberia, and Greenland, also from North America, Persia, and China.

Similarly, the Schizæaceæ were among the more abundant ferns in the Jurassic vegetation. The Cyatheaceæ, a family that is now for the most part confined to the tropics, constituted another vigorous and widely spread section in the Jurassic period; we find them in Jurassic rocks of Victoria, as well as in several regions in Europe, North America, and the Arctic regions.

The fertile fronds of many of the fossil Cyatheaceæ bear a striking resemblance to that isolated survivor of the family in Juan Fernandez—*Thyrsopteris elegans*. It is true that a considerable number of ferns of Jurassic and Wealden age have been described by the generic name *Thyrsopteris* without any adequate reason; but, neglecting all doubtful forms, there remain several types represented in the Jurassic flora of Siberia, England, and other parts of the world, which enable us to refer them with confidence to the Cyatheaceæ and to compare them more particularly with the sole existing species of *Thyrsopteris*. The Gleicheniaceæ, at present characteristic of tropical and southern countries, were undoubtedly abundant in the northern hemisphere in early Cretaceous days; abundant traces of this family are recorded from Greenland as well as from more southern European latitudes.

One of the most striking facts afforded by a study of the Mesozoic ern vegetation is the former extension and vigorous development of wo families, the Dipteridinæ and Matonineæ, which are now onfined to a few tropical regions and represented by six species. The fertile fragment of a frond of *Matonidium* exposed by a stroke f the hammer in a piece of iron-stained limestone picked up on the beach at Haiburn Wyke (a few miles north of Scarborough), is hardly distinguishable from a pinna of the Malayan *Matonia pectinata.* Rhætic and Jurassic ferns referred to the genus *Laccopteris* afford other examples of the abundance of the Matonineæ in the northern hemisphere during the earlier part of the Mesozoic era.

The modern genus *Dipteris,* with its four species occurring in India, the Malayan region, Formosa, Fiji, and New Caledonia, stands apart from the great majority of Polypodiaceous ferns, and is now placed in a separate family—the Dipteridinæ. Like *Matonia* it is essentially an ancient and moribund type with hosts of ancestors included in such Rhætic and Jurassic genera as *Dictyophyllum, Camptopteris,* and others which must have been among the most conspicuous and vigorous members of the Mesozoic vegetation.

E. *Flowering Plants.*—Our retrospect of the march of plant-life has so far extended to the dawn of the Cretaceous period, a chapter in geological history written in the rocks that constitute the Wealden series of Britain exposed in the Sussex cliffs and in the Weald district of south-east England. According to the geologist's reckoning, the Cretaceous period is of comparatively modern date; it occupies a position near the summit of a long succession of ages representing an amount of time beyond the power of imagination to conceive.

One interesting fact as regards the composition of the Jurassic flora is the absence of any plants that can reasonably be identified as Angiosperms. In the Wealden flora of England no vestige of an Angiosperm has been found; this statement holds good also as regards Wealden floras in most other regions of the world. On the other hand, as soon as we ascend to strata of slightly more recent age we are confronted with a new element in the vegetation, which with amazing rapidity assumes the leading rôle. It is impossible to say with confidence at what precise period of geological history the Angiosperms appeared. When the rocks that now form the undulating country of the Weald were being accumulated as river-borne sediments on the floor of an estuary, this crowning act in the drama of plant evolution was probably being enacted.

I have already pointed out that we have as yet recognised no Angiosperms in the Wealden floras of England, Spitzbergen, Germany, France, Austria, Belgium, Russia, and Japan; but from plant-bearing rocks of Portugal, regarded as homotaxial with those which British geologists speak of as Wealden, the late Marquis of Saporta named a fragment of a leaf *Alismacites primævus,* a determination that, while possibly correct, cannot be accepted as conclusive testimony. In Virginia and Maryland there occurs a thick series of strata known as the Potomac formation, from which a rich harvest of plant-remains has been obtained. Professor Lester Ward has recently shown that under this title are included several floras, some of which are undoubtedly homotaxial with the Wealden of Europe, while others represent the vegetation of a later phase of the Cretaceous era. From the older Potomac beds a few leaves have been assigned to Dicotyledons and referred to such genera as *Ficophyllum*, *Myrica*, *Proteæphyllum*, and others. Some of these may well be small fronds of ferns with venation characters like those of the Elk's Horn fern (*Platycerium*), while others, though presenting a close resemblance to Dicotyledonous leaves, afford insufficient data for accurate generic identification. In dealing with fossil leaves of the dicotyledonous type, we must not forget that the recent genus *Gnetum*—a gymnosperm of the section Gnetales—possesses leaves that may be said to be indistinguishable in form and venation from those of certain Dicotyledons. Before the close of the Potomac period these few fragmentary relics of possible Dicotyledons are replaced by a comparative abundance of specimens which must be accepted as undoubted Angiosperms. Previous to the discovery of the supposed Angiosperms in Wealden strata of Portugal and North America, the earliest record of an Angiosperm was represented by Heer's *Populus primæva* from Northern Greenland. This name was applied to a fragmentary specimen which may be a true dicotyledonous leaf. In 1897 Dr. White, of the Geological Survey of the United States, stated that additional examples of dicotyledonous leaves had been obtained during the visit of the Peary Arctic expedition to the well-known locality in Greenland where Heer's *Populus primæva* was discovered in the so-called Kome series. From strata known as the Atane beds, which rest on the Kome series, unmistakable Angiosperms have been collected in abundance.

Another indication of the sudden increase in the number of dicotyledons is furnished by the Dakota flora of the United States—in age somewhat more recent than the older Potomac beds. In these plant-beds it is stated that Angiosperms constitute two-thirds of the vegetation.

One of our most pressing needs is a thoroughly critical revision of the late Cretaceous and earlier Tertiary floras, with the object both of determining the systematic position of the older Angiosperms and of mapping out with greater accuracy the geographical distribution of the floras of the world in post-Wealden periods. This is a task which is sometimes said to be impossible or hardly worth the attempt; the available evidence is indeed meagre, and much of it has been treated with more respect than it deserves, but it is at least a praiseworthy aim, not to say a duty, to take stock of our material and to compile lists of plants that may bear the scrutiny of experienced systematists. We are profoundly ignorant of the means by which Nature produced this new creation; we can only emphasise the fact that in the early days of the Cretaceous era a new type was evolved which no sooner appeared than it swept all before it, and by its overmastering superiority converted the past into the present.

In conclusion, I would urge the importance of taking stock of our accumulated facts, and of so recording our observations that they may be safely laid under contribution as aids to broad generalisations. Detailed descriptions and the enumeration of small collections are a necessity, but there is danger of the student neglecting the application of his results to problems of far-reaching import.

There is no more fascinating task than to follow the onward march of the plant-world from one stage to another and to watch the fortunes of the advancing army. We see from time to time war-worn veterans dropping from the ranks and note the constant addition of recruits, some of whom march but a short distance and fall by the way; while others, better equipped, rise to a position of importance.

At long intervals the formation is altered and the constitution of the advancing and increasing host is suddenly changed; familiar leaders are superseded by newcomers, who mark their advent by drastic reorganisation. To change the metaphor, we may compare the stages of plant-evolution to the records of changing architectural styles represented in Gothic buildings. The simple Norman arch and massive pier are replaced, with apparent suddenness, by the pointed arch and detached shafts of the thirteenth century; the latter style, which marked an architectural phase characterised by local variations subordinated to a uniformity in essential features, was replaced by one in which simplicity was superseded by elaboration, and new elements were added leading to greater complexity and a modification of plan. Similarly, the Palæozoic facies of vegetation passes with almost startling suddenness into that which monopolised the world in the Mesozoic era, and was in turn superseded by the more highly elaborated and less homogeneous vegetation of the Cretaceous and Tertiary periods. In taking a superficial view of architectural styles we are apt to lose sight of the signs of gradual transition by which one period passes into the next; so, too, in our retrospect of the changing scenes which mark the progress of plant-evolution, we easily overlook the introduction of new types and the gradual substitution of new for old. The invention of a new principle in the construction of buildings is soon followed by its wide adoption; new conceptions become stereotyped, and in a comparatively few years the whole style is altered. As a new and successful type of plant-architecture is produced it rapidly comes into prominence and acts as the most potent factor in changing the facies of a flora. Making due allowances for the imperfection of the geological record, we cannot escape from the conclusion, which is by no means opposed to our ideas of the operation of the laws governing evolutionary forces, that the state of equilibrium in the vegetable kingdom was rudely shaken during two revolutionary periods. The earlier transitional period occurred when Conifers and Cycads became firmly established, while for the second revolution the introduction of the Angiospermous type was mainly responsible. As in the half-effaced documents accessible to the student of architecture "the pedigrees of English Gothic can still be recovered," so also we are able to trace in the *registers imprinted* on the rocks the genealogies of existing *botanical types.*

II.—A THEORY OF THE ORIGIN OF CONTINENTS AND OCEAN BASINS.

By WILLIAM MACKIE, M.A., M.D.[1]

WHATEVER the conditions at present obtaining in the interior of the earth, it is naturally supposed to have originally passed through a stage which would be represented by a solid, or potentially solid, nucleus, a slowly forming and slowly thickening acid crust, with a liquid and more or less basic interstratum. At first the crust would be sufficiently flexible to accommodate itself to the tidal movements of the subjacent liquid interstratum, but when it became too rigid to admit of this tidal movement it would be broken up, the fracture probably following certain fairly defined and assignable lines. It is argued that the fragments would not have 'gone under,' but would have remained with their surfaces at a considerably higher level than the surface of the magma, and have become so fixed by consolidation of the magma around them.

It is suggested that the first great breach in the crust followed the outline of the tidal protuberance, and was, in all probability, effected at some conjunction of the sun and moon with cataclysmal suddenness, the intervening crust being shivered into small fragments, these fragments being subsequently disposed of by fusion in and incorporation with the magma. The first oval breach thus caused is the prototype of the Pacific Ocean. Further fractures, it is suggested, gave rise to the other oceans, and caused the separation of the continents. Under the influence of tidal retardation the fragments as thus blocked out became separated and finally moored at their respective distances by the solidification of the magma around them.

With the resolidification of the crust, a series of stresses was set up between the ocean basins, which consisted of the more basic, consequently specifically heavier, more quickly conducting material, and the more acid, specifically lighter, more slowly conducting continental masses. The former are, in consequence of their character and composition, the more stable portions of the resolidified crust. Further cooling therefore leads to their sinking down on the cooling and shrinking nucleus, and their elbowing aside of the continental masses, which come to be elevated in lines parallel to and extending along their margins. With further cooling the superficial layers of the continents are thrown into folds and overfolds, which would tend to find relief along the ocean margins by thrusts directed from the continents towards the oceans. Central uplifts in the continental areas also may have resulted from such pressure.

The tendency of the ocean to become deeper and the continent to become more elevated as time goes on, leads more and more to the withdrawal of the waters of the ocean (which might at first almost or altogether have covered the continental areas) from these areas, and hence to greater and greater restriction in the limits of the areas of deposit as traced from earlier to later geological times.

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[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

The origin of the Mediterranean is separately dealt with, and the cause of the unequal distribution of land and sea in the northern and southern hemispheres is discussed.

Though the contraction of the ocean basins has been the main cause of the deformation of the crust, the contraction of the continental areas has also had some share in the result. The central ridge of the Atlantic bottom may be an earth fold caused by pressure of the contiguous continental masses; but it may also be due to longitudinal fissures permitting volcanic action and consequent accumulation of volcanic products, the fissures in such case marking the relief of tension arising from the same cause.

The formation of secondary ridges parallel to the oceano-continental margins, but at some distance towards the continental side, seems to have played an important part in the evolution. Extending oceanwards in their operation they appear in some instances to have raised up portions of the ocean bottom into continuity with the land surface. In this way, with the aid of volcanic action, the ocean basins appear, in not a few instances, to have been successfully bridged. As the permanency of the master features of the globe in much their present form is a necessary corollary of the theory, such bridging of the ocean basins also becomes a necessary part of the theory, and is fairly met on the lines indicated.

Explaining as it does the general outlines of continents and ocean basins, as well as a large number of facts both in geography and geology, it is contended that the theory as sketched does represent in a general way the actual process by which the permanent features of the globe took origin.

III.—ON THE LAKES OF THE UPPER ENGADINE. By ANDRÉ DELEBECQUE.[1]

ONE of the most striking instances of a long depression forming a pass between two valleys, and occupied by a series of lakes, is to be seen in the strip of land which extends between St. Moriz and the Maloja. It is occupied by the four lakes of Sils, Silva Plana, Lampfer, and St. Moriz, with a depth of 71, 77, 34, and 44 metres respectively. The level of these lakes ranges between 1,771 and 1,800 metres. The lake of St. Moriz is obviously in a rock-basin.

As to the other three lakes, an opinion concurrently prevails which, though supported by the high authority of Professor Heim, is believed by the author to be unjustified. It is generally thought that the river Inn, weakened by the capture of some of its tributaries by the river Maira, has been unable to sweep away the deposits of the torrents descending from lateral valleys, and that consequently its waters have been dammed up into the three lakes in question.

An attentive survey of the region shows that, on the contrary, these lakes formerly constituted a single sheet of water in a rock-basin, which extended from the Maloja to the village of Lampfer, in both of which places ledges of gneiss are visible, and that the lateral torrents, far from contributing to the formation of the lakes, have partly filled them up by their deposits, and have divided into three what was occasionally a single basin.

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The length of the original lake was remarkable, as it measured no less than 12 kilometres (7½ miles), and it must be borne in mind that though mountain lakes are often very deep their horizontal dimensions are generally limited.

As to the origin of the lake, the author is of opinion that it cannot be attributed to tectonic movements cr to aqueous erosion, and that very probably glacial excavation has come into play.

IV.—Geology of the Country round Southport. By J. Lomas, A.R.C.S., F.G.S.[1]

LOOKING towards Southport from the sea, we notice three platforms rising in gigantic steps towards the east.

The first is low, varying in height from 9 to 20 feet above Ordnance datum, and is fringed on the seaward side by sandhills which rise to an elevation of from 50 to 90 feet. On the north the broad estuary of the Ribble separates this plain from a similar platform known as the Fylde district, and the Mersey on the south cuts off another fragment which forms the north end of the Wirral. Two less significant streams, the Douglas and the Alt, flow across the platform into the Ribble estuary and the Crosby Channel respectively.

The whole of this plain is the gift of the Irish Sea glacier, which formerly overrode the district, the solid rocks only reaching the surface in the case of a few islands, while the bulk is below sea-level.

In the immediate neighbourhood of Southport, Keuper marls occur. These are of great thickness, and contain bands of gypsum and pseudomorphs of rock-salt. To the north, in the Fylde district, where similar rocks occur, salt is obtained from the beds, and the boulders of gypsum which occur in great profusion in the local drift have evidently come from this formation.

The Bunter rocks of the Trias succeed to the east, and are in places capped by Keuper sandstones. Where these occur we reach the second platform.

At Ormskirk, distant about eight miles from Southport, several interesting sections show the Keuper resting on the Upper Bunter. At Scarth Hill, near the Water Tower, the relations between Keuper and Bunter are well displayed, and the quarries are worth visiting. Probably nowhere in the district do the Bunter sandstones display such clear evidence of their æolian origin. They consist of sand-grains perfectly rounded and polished, each bed containing grains of uniform size. So perfect is this sifting that it looks as if the layers had been passed through sieves of varying meshes. In some layers the grains are 2 mm. in diameter, and in others they are exceedingly fine. A comparison of these sands with others from the Sahara and sand-dunes shows clearly the distinction between the deposition by wind agency and in water. Faults traversing the Triassic rocks conform to the general N. and S. direction so characteristic of Lancashire and Cheshire, and these are joined by E. and W. faults, which, as a rule, have little or no throw. It seems as if the N. and S. buckling which caused the main faults had cut up the rocks into blocks, and the E. and W. faults mark the units which dropped successively in the individual blocks.

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Further to the east the Bunter rocks give place to Coal-measures, but at one or two places in the area, as at Skillaw Clough and Bentley Brook, thin beds of Permian age intervene.

Succeeding the Coal-measures, Millstone Grit appears in the next platform, which forms the hills above Chorley and Horwich. An outlier of Millstone Grit also occurs at Parbold, further to the west.

The disposition of the rocks already given indicate an approach towards the arch of the great Pennine anticline, and on crossing the Pennine chain a similar succession, in the reverse order, is met with in Yorkshire.

The matter is complicated, however, by the occurrence of another line of folding which shows itself in the Rosendale anticline, running E.N.E. to W.S.W.; and it is owing to this cross folding that the Millstone Grit is brought to the surface on Anglezark Moor and at Parbold.

As a result of this folding the main faults in the Carboniferous area run parallel with the anticline, and the cross faults at right angles to the faulted blocks are characterised by having only a slight throw.

Returning now to the first platform, we find the chief interest lies in the glacial and post-glacial deposits which cover the area. The surface of the Boulder-clay is very uneven, and in the hollows meres have been found. Many of these have since been filled with peat, and tree trunks, both prone and erect, are found enclosed in it. A great number of these meres, or mosses, are seen, not only about Southport, but in the Fylde, in South Lancashire, and the northern part of Cheshire.

In all cases they either drain eastwards or formerly did so. Borings in the peat show that they often extend below sea-level, and there must have existed barriers which prevented the waters from reaching the Irish Sea. It has been estimated that the coasts in the neighbourhood are being eroded, in some places at the rate of five yards a year; so that 400 years ago the land would extend more than a mile seawards; and if the same rate of waste has obtained since the Glacial period there would be a land of meres and mosses extending as far as the Isle of Man. It is possible that the Irish elk found in the Isle of Man crossed by this lost land.

Along the coast meres can be seen in all stages of decay. Immediately to the east of Southport lies Martin Mere, which is only separated from the sea by a narrow bank at Crossens. At the Alt mouth, at Leasowe, in Cheshire, and in other places, the ancient meres have been cut in two by the sea, and we have peat and tree

trunks on the coast below high-water level. These are usually spoken of as 'submerged forests,' and their occurrence in the places mentioned may indicate a lowering of the surface of the land since the trees grew.

The present mouths of the Mersey, Alt, Douglas, and Ribble have all been cut through ancient meres, and as there is evidence that these formerly drained to the east it is probable that the breaching of the meres has resulted in a reversal of flow since Glacial times, and the present mouths are of comparatively recent date.

The sandhills on the coast only occur in districts adjacent to rivers. It is probable that they owe their origin to the material brought down by the rivers, forming a bank of sand in the slack water at each side of their channels. These banks drying at low water, the sand has then been blown inland by the prevailing south-west winds. No dunes existed in this district 400 years ago, and they are probably subsequent to and result from the reversal of the drainage of the Mersey and Ribble.

V.—DIATOMACEOUS EARTH AT LAKE GNANGARA, WESTERN AUSTRALIA.

THE Government Geologist of Western Australia reports the discovery of an extensive deposit of Diatomaceous earth at Lake Gnangara, in the Wanneroo district. It is composed almost entirely of the skeletons of Diatoms, and of the spicules of fresh-water sponges (Spongilla). The main deposit forms a quaking bog, with a smooth surface, starting immediately at the foot of the sandy banks on the northern shore of the lake at a height of a few inches above water-level, and sloping gradually towards the lake, beneath the surface of which it passes. The whole deposit is covered with a scanty growth of reeds, and, from all appearances, is still in process of formation. The deposit occupies the northern and western edges of Lake Gnangara, a permanent fresh-water lake eleven miles due north from Perth, and about four miles north-east of Wanneroo. Under the microscope, the earth is seen to be composed of a felted mass of siliceous spicules, in which are embedded numerous diatom frustules, of perfect form. They belong mainly to the groups of *Naviculeæ* and *Eunotieæ*, a very large species of *Pinnularia* being especially noticeable. The genus *Bacillaria*, which is said to yield the best dynamite, is apparently entirely absent. The Wanneroo earth would not appear to be well suited for the manufacture of dynamite, owing to the high percentage of alumina in it, and also owing to the forms of the diatoms present in it. It is, however, eminently suited for the manufacture of disinfectants by the absorption of phenol, etc., as well as for lining cold-storage rooms, and railway wagons, and as an ingredient for refrigerating paint. Owing to the extremely small percentage of iron and other mineral impurity present, it would be an excellent source of silica for the manufacture of soluble and other glass. It could also be used as an ingredient of metal-polishing powders and soaps. For all these purposes it would require to be calcined and crushed.

VI.—A Method of Facilitating Photography of Fossils, by Gilbert van Ingen.

A SIMPLE apparatus has been devised by which a fossil of any size can be coated with a thin, opaque, white film which effectually illuminates under the influence of both colour and reflected light. The necessary articles for construction of the apparatus are: a foot-blower, large wide-mouthed bottle of gallon capacity, with three-holed rubber stopper, two bottles of quart capacity, each with two-holed rubber stopper, glass tubing of one-eighth-inch bore and rubber tubing to fit same (three feet of each), two U-shaped calcium chloride tubes filled with chloride, strong ammonia water, strong HCl. To use: Air from the foot-blower is forced into the large bottle, which equalises the pressure, and thence through the ammonia water and HCl into the smaller bottles. The air, mixed with the gases taken up, is passed through the calcium chloride tubes, where the moisture is extracted, and escapes through the two glass tubes held in the hands at a short distance from the object to be coated. The union of the two gases escaping from the tubes forms ammonium chloride, which settles as an exceedingly fine powder upon the surface of the specimens. The coating thus obtained, when deposited slowly, is of a dead white, which effectually hides all coloration of the surface, and, instead of obliterating the finer modelling, renders the details of the topography with the utmost distinctness. Some surfaces take the coating more readily than others. Fine-grained black limestones and all other rocks that present a velvety surface take the coating well. Porous rocks are difficult to cover. Specimens which have been handled must be washed with benzene. The coating of the salt is perfectly harmless, and may readily be removed by water, gentle heating, or the use of a soft brush. Photographs of such coated specimens fulfil more nearly the requirements of the work than do those taken by the ordinary methods. The coating is also of great assistance in the elucidation of the details of small species, as was found to advantage while studying the lobation of the heads of small trilobites.—*Annals N.Y. Acad. Sci.*, xiv, pp. 115, 116; March, 1902.

REVIEWS.

I.—Annual Reports of the Geological Commission of the Cape of Good Hope for the Years 1901 and 1902.

THESE two volumes, issued by the Department of Agriculture of the Cape of Good Hope, reach the same standard of excellence as previous publications, both with respect to the style in which they are presented and the important and interesting matter they contain.

Since the last Report the Scientific staff has undergone some change. Dr. G. S. Corstorphine retired from the Directorship in *1901, and was succeeded* by Mr. A. W. Rogers under the title of

Acting Geologist, with a field staff consisting of Messrs. E. H. L. Schwarz and Alex. L. du Toit; while Miss M. Wilman acts as Museum Assistant.

The field work for the two years embraced by the Reports chiefly lay among rocks ranging in age from the Karroo formation upwards, the older rocks forming in proportion only a small amount of the area examined. The account of the Karroo beds, with their numerous and peculiar reptilian remains, and the great extent of the volcanic and igneous activity displayed, affords interesting reading. Very suggestive, too, are the remarks by Mr. Schwarz on the lavas of the Drakensberg and on the line of volcanoes trending parallel with the eastern coast, implying a line of weakness and an axis of folding in this direction. He naturally concludes that the shelving sea-shores at present existing off the southern coast may be explained by the gradual sinking of the sea-bottom without rupture, and that there is no necessity to invoke the aid of great faults.

The Cretaceous rocks and Superficial Deposits are carefully and fully described, while questions of economic importance receive due attention. A petrological account of the Rocks of Matatiele, by Mr. Schwarz, accompanies the Report for 1902, and the geological maps of parts of the Division of Matatiele and of the Igneous Rocks of Kentani, though somewhat roughly reproduced, will be found a distinct addition to the Reports.

It is a matter for congratulation that the fossils collected since the commencement of the Survey are in the hands of specialists, and that the descriptions are to be published in a special volume of the Annals of the South African Museum. We hope that good figures will accompany the descriptions.

The Report for 1901 contains an account of a journey from Swellendam to Mount Bay; a general survey of the rocks in the southern part of the Transkei and Pondoland, including a description of the Cretaceous rocks of Eastern Pondoland; and a Geological Survey of the Division of Kentani. The work, owing to the war, had to be carried on in the native reservation, instead of being continued in the Western Provinces, and this somewhat breaks the thread of previous Reports. The results obtained are, however, of considerable interest. The account of the igneous intrusions in Pondoland deserves especial attention, more particularly the following passage:—"Along the banks of the Great Kei River, north of the Bridge, there are some very fine examples of the laccolitic form of intrusion of the dolerite, but what strikes one at once is that the sedimentary rocks do not seem to have been arched up over the dome-shaped masses of igneous rocks; the contacts are not well shown, but it certainly looks as if the strata had disappeared in the space occupied by the igneous rocks, and the ends of the beds seem to abut against the rounded contours of the dolerite, a fact which we again and again noticed throughout the Territories, and which was beautifully shown in the sections of actual contacts along the Kentani coast."

Among other points of interest we may notice the description of the richly fossiliferous Cretaceous rocks (Umtamvuna Beds of Mr. Dunn's map, Izinhluzabalungu deposits of Griesbach); and the field evidence obtained as to the correlation of the Enon Conglomerate and Uitenhage Series.

The Report for 1902 contains an excellent summary of the year's work by Mr. Rogers, which consisted of an examination of the Matatiele Division by Mr. Schwarz, and parts of the Divisions of Beaufort West, Prince Albert, and Sutherland, by Messrs. Rogers and Schwarz. The account of the volcanic rocks of Matatiele by Mr. Schwarz contains much interesting matter, not the least important being the discovery of a whole series of volcanic necks in such positions as indicate that large parts of the Drakensberg and Maluti Ranges were formerly chains of volcanoes, and that they owe their elevation to these causes.

The higher parts of East Griqualand, Mr. Schwarz considers, offer a good field for the search for workable seams of coal, which would probably lie on about the same horizon as those of Indwe.

In the Western Province a nearly complete skeleton of *Pareiasaurus serridens*, weighing 700 lbs., was obtained and sent to Cape Town, where it is to be set up in the Cape Museum. Many other reptilian remains of great interest were also obtained, and the belief is expressed that the Karroo System will be satisfactorily subdivided by their means when they are sufficiently collected and described.

Not the least welcome feature of the Report for 1902 will be the following table of the classification of the Sedimentary Rocks of the Colony, of which we hope Mr. Rogers' anticipation that it will not require any considerable alteration in the near future will be realized :—

			In the Transkei.
SUPERFICIAL DEPOSITS.	Dune sands, and limestone derived from them. Alluvial muds, sands, and gravels near the present levels of the rivers. Laterite. Estuarine deposits containing foraminifera and *Cryptodon globosus*. Quartzitic rocks and ironstone gravels, representing older river deposits and laterites.		
	Pondoland Cretaceous Series.		
	Uitenhage Series.		
KARROO SYSTEM.	STORMBERG SERIES.	Volcanic Beds. Cave Sandstone. Red Beds. Molteno Beds.	
	BEAUFORT SERIES.	Zone of Specialized Theriodonts.	Kentani Beds.
		Dicynodon Beds. *Pareiasaurus* Beds.	Idutywa Beds.
	ECCA SERIES.	Shales and thin sandstones. Laingsburg Beds. Shales.	Umsikaba Beds.
	DWYKA SERIES.	Upper Shales. Conglomerate. Lower Shales.	

II.—A THEORY OF THE ORIGIN OF CONTINENTS AND OCEAN BASINS.

By WILLIAM MACKIE, M.A., M.D.[1]

WHATEVER the conditions at present obtaining in the interior of the earth, it is naturally supposed to have originally passed through a stage which would be represented by a solid, or potentially solid, nucleus, a slowly forming and slowly thickening acid crust, with a liquid and more or less basic interstratum. At first the crust would be sufficiently flexible to accommodate itself to the tidal movements of the subjacent liquid interstratum, but when it became too rigid to admit of this tidal movement it would be broken up, the fracture probably following certain fairly defined and assignable lines. It is argued that the fragments would not have 'gone under,' but would have remained with their surfaces at a considerably higher level than the surface of the magma, and have become so fixed by consolidation of the magma around them.

It is suggested that the first great breach in the crust followed the outline of the tidal protuberance, and was, in all probability, effected at some conjunction of the sun and moon with cataclysmal suddenness, the intervening crust being shivered into small fragments, these fragments being subsequently disposed of by fusion in and incorporation with the magma. The first oval breach thus caused is the prototype of the Pacific Ocean. Further fractures, it is suggested, gave rise to the other oceans, and caused the separation of the continents. Under the influence of tidal retardation the fragments as thus blocked out became separated and finally moored at their respective distances by the solidification of the magma around them.

With the resolidification of the crust, a series of stresses was set up between the ocean basins, which consisted of the more basic, consequently specifically heavier, more quickly conducting material, and the more acid, specifically lighter, more slowly conducting continental masses. The former are, in consequence of their character and composition, the more stable portions of the resolidified crust. Further cooling therefore leads to their sinking down on the cooling and shrinking nucleus, and their elbowing aside of the continental masses, which come to be elevated in lines parallel to and extending along their margins. With further cooling the superficial layers of the continents are thrown into folds and overfolds, which would tend to find relief along the ocean margins by thrusts directed from the continents towards the oceans. Central uplifts in the continental areas also may have resulted from such pressure.

The tendency of the ocean to become deeper and the continent to become more elevated as time goes on, leads more and more to the withdrawal of the waters of the ocean (which might at first almost or altogether have covered the continental areas) from these areas, and hence to greater and greater restriction in the limits of the areas of deposit as traced from earlier to later geological times.

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The origin of the Mediterranean is separately dealt with, and the cause of the unequal distribution of land and sea in the northern and southern hemispheres is discussed.

Though the contraction of the ocean basins has been the main cause of the deformation of the crust, the contraction of the continental areas has also had some share in the result. The central ridge of the Atlantic bottom may be an earth fold caused by pressure of the contiguous continental masses; but it may also be due to longitudinal fissures permitting volcanic action and consequent accumulation of volcanic products, the fissures in such case marking the relief of tension arising from the same cause.

The formation of secondary ridges parallel to the oceano-continental margins, but at some distance towards the continental side, seems to have played an important part in the evolution. Extending oceanwards in their operation they appear in some instances to have raised up portions of the ocean bottom into continuity with the land surface. In this way, with the aid of volcanic action, the ocean basins appear, in not a few instances, to have been successfully bridged. As the permanency of the master features of the globe in much their present form is a necessary corollary of the theory, such bridging of the ocean basins also becomes a necessary part of the theory, and is fairly met on the lines indicated.

Explaining as it does the general outlines of continents and ocean basins, as well as a large number of facts both in geography and geology, it is contended that the theory as sketched does represent in a general way the actual process by which the permanent features of the globe took origin.

III.—ON THE LAKES OF THE UPPER ENGADINE. By ANDRÉ DELEBECQUE.[1]

ONE of the most striking instances of a long depression forming a pass between two valleys, and occupied by a series of lakes, is to be seen in the strip of land which extends between St. Moriz and the Maloja. It is occupied by the four lakes of Sils, Silva Plana, Lampfer, and St. Moriz, with a depth of 71, 77, 34, and 44 metres respectively. The level of these lakes ranges between 1,771 and 1,800 metres. The lake of St. Moriz is obviously in a rock-basin.

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ONE of the most striking instances of a long depression forming a pass between two valleys, and occupied by a series of lakes, is to be seen in the strip of land which extends between St. Moriz and the Maloja. It is occupied by the four lakes of Sils, Silva Plana, Lampfer, and St. Moriz, with a depth of 71, 77, 34, and 44 metres respectively. The level of these lakes ranges between 1,771 and 1,800 metres. The lake of St. Moriz is obviously in a rock-basin.

As to the other three lakes, an opinion concurrently prevails which, though supported by the high authority of Professor Heim, is believed by the author to be unjustified. It is generally thought that the river Inn, weakened by the capture of some of its tributaries by the river Maira, has been unable to sweep away the deposits of the torrents descending from lateral valleys, and that consequently its waters have been dammed up into the three lakes in question.

An attentive survey of the region shows that, on the contrary, these lakes formerly constituted a single sheet of water in a rock-basin, which extended from the Maloja to the village of Lampfer, in both of which places ledges of gneiss are visible, and that the lateral torrents, far from contributing to the formation of the lakes, have partly filled them up by their deposits, and have divided into three what was occasionally a single basin.

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[1] *Abstract of paper read before the British Association,* Southport, September, 1903, *in Section C (Geology).*

The length of the original lake was remarkable, as it measured no less than 12 kilometres (7½ miles), and it must be borne in mind that though mountain lakes are often very deep their horizontal dimensions are generally limited.

As to the origin of the lake, the author is of opinion that it cannot be attributed to tectonic movements or to aqueous erosion, and that very probably glacial excavation has come into play.

IV.—GEOLOGY OF THE COUNTRY ROUND SOUTHPORT. By J. LOMAS, A.R.C.S., F.G.S.[1]

LOOKING towards Southport from the sea, we notice three platforms rising in gigantic steps towards the east.

The first is low, varying in height from 9 to 20 feet above Ordnance datum, and is fringed on the seaward side by sandhills which rise to an elevation of from 50 to 90 feet. On the north the broad estuary of the Ribble separates this plain from a similar platform known as the Fylde district, and the Mersey on the south cuts off another fragment which forms the north end of the Wirral. Two less significant streams, the Douglas and the Alt, flow across the platform into the Ribble estuary and the Crosby Channel respectively.

The whole of this plain is the gift of the Irish Sea glacier, which formerly overrode the district, the solid rocks only reaching the surface in the case of a few islands, while the bulk is below sea-level.

In the immediate neighbourhood of Southport, Keuper marls occur. These are of great thickness, and contain bands of gypsum and pseudomorphs of rock-salt. To the north, in the Fylde district, where similar rocks occur, salt is obtained from the beds, and the boulders of gypsum which occur in great profusion in the local drift have evidently come from this formation.

The Bunter rocks of the Trias succeed to the east, and are in places capped by Keuper sandstones. Where these occur we reach the second platform.

At Ormskirk, distant about eight miles from Southport, several interesting sections show the Keuper resting on the Upper Bunter. At Scarth Hill, near the Water Tower, the relations between Keuper and Bunter are well displayed, and the quarries are worth visiting. Probably nowhere in the district do the Bunter sandstones display such clear evidence of their æolian origin. They consist of sand-grains perfectly rounded and polished, each bed containing grains of uniform size. So perfect is this sifting that it looks as if the layers had been passed through sieves of varying meshes. In some layers the grains are 2 mm. in diameter, and in others they are exceedingly *fine*. A comparison of these sands with others from the Sahara and sand-dunes shows clearly the distinction between the deposition by wind agency and in water. Faults traversing the Triassic rocks conform to the general N. and S. direction so characteristic of Lancashire and Cheshire, and these are joined by E. and W. faults, which, as a rule, have little or no throw. It seems as if the N. and S. buckling which caused the main faults had cut up the rocks into blocks, and the E. and W. faults mark the units which dropped successively in the individual blocks.

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[1] Abstract of paper read before the British Association, Southport, Section C (*Geology*), September, 1903.

Further to the east the Bunter rocks give place to Coal-measures, but at one or two places in the area, as at Skillaw Clough and Bentley Brook, thin beds of Permian age intervene.

Succeeding the Coal-measures, Millstone Grit appears in the next platform, which forms the hills above Chorley and Horwich. An outlier of Millstone Grit also occurs at Parbold, further to the west.

The disposition of the rocks already given indicate an approach towards the arch of the great Pennine anticline, and on crossing the Pennine chain a similar succession, in the reverse order, is met with in Yorkshire.

The matter is complicated, however, by the occurrence of another line of folding which shows itself in the Rosendale anticline, running E.N.E. to W.S.W.; and it is owing to this cross folding that the Millstone Grit is brought to the surface on Anglezark Moor and at Parbold.

As a result of this folding the main faults in the Carboniferous area run parallel with the anticline, and the cross faults at right angles to the faulted blocks are characterised by having only a slight throw.

Returning now to the first platform, we find the chief interest lies in the glacial and post-glacial deposits which cover the area. The surface of the Boulder-clay is very uneven, and in the hollows meres have been found. Many of these have since been filled with peat, and tree trunks, both prone and erect, are found enclosed in it. A great number of these meres, or mosses, are seen, not only about Southport, but in the Fylde, in South Lancashire, and the northern part of Cheshire.

In all cases they either drain eastwards or formerly did so. Borings in the peat show that they often extend below sea-level, and there must have existed barriers which prevented the waters from reaching the Irish Sea. It has been estimated that the coasts in the neighbourhood are being eroded, in some places at the rate of five yards a year; so that 400 years ago the land would extend more than a mile seawards; and if the same rate of waste has obtained since the Glacial period there would be a land of meres and mosses extending as far as the Isle of Man. It is possible that the Irish elk found in the Isle of Man crossed by this lost land.

Along the coast meres can be seen in all stages of decay. Immediately to the east of Southport lies Martin Mere, which is only separated from the sea by a narrow bank at Crossens. At the Alt mouth, at Leasowe, in Cheshire, and in other places, the ancient meres have been cut in two by the sea, and we have peat and tree trunks on the coast below high-water level. These are usually spoken of as 'submerged forests,' and their occurrence in the places mentioned may indicate a lowering of the surface of the land since the trees grew.

The present mouths of the Mersey, Alt, Douglas, and Ribble have all been cut through ancient meres, and as there is evidence that these formerly drained to the east it is probable that the breaching of the meres has resulted in a reversal of flow since Glacial times, and the present mouths are of comparatively recent date.

The sandhills on the coast only occur in districts adjacent to rivers. It is probable that they owe their origin to the material brought down by the rivers, forming a bank of sand in the slack water at each side of their channels. These banks drying at low water, the sand has then been blown inland by the prevailing south-west winds. No dunes existed in this district 400 years ago, and they are probably subsequent to and result from the reversal of the drainage of the Mersey and Ribble.

V.—DIATOMACEOUS EARTH AT LAKE GNANGARA, WESTERN AUSTRALIA.

THE Government Geologist of Western Australia reports the discovery of an extensive deposit of Diatomaceous earth at Lake Gnangara, in the Wanneroo district. It is composed almost entirely of the skeletons of Diatoms, and of the spicules of fresh-water sponges (Spongilla). The main deposit forms a quaking bog, with a smooth surface, starting immediately at the foot of the sandy banks on the northern shore of the lake at a height of a few inches above water-level, and sloping gradually towards the lake, beneath the surface of which it passes. The whole deposit is covered with a scanty growth of reeds, and, from all appearances, is still in process of formation. The deposit occupies the northern and western edges of Lake Gnangara, a permanent fresh-water lake eleven miles due north from Perth, and about four miles north-east of Wanneroo. Under the microscope, the earth is seen to be composed of a felted mass of siliceous spicules, in which are embedded numerous diatom frustules, of perfect form. They belong mainly to the groups of *Naviculeæ* and *Eunotieæ*, a very large species of *Pinnularia* being especially noticeable. The genus *Bacillaria*, which is said to yield the best dynamite, is apparently entirely absent. The Wanneroo earth would not appear to be well suited for the manufacture of dynamite, owing to the high percentage of alumina in it, and also owing to the forms of the diatoms present in it. It is, however, eminently suited for the manufacture of disinfectants by the absorption of phenol, etc., as well as for lining cold-storage rooms, and railway wagons, and as an ingredient for refrigerating paint. Owing to the extremely small percentage of iron and other mineral impurity present, it would be an excellent source of silica for the manufacture of soluble and other glass. It could also be used as an ingredient of metal-polishing powders and soaps. For all these purposes it would require to be calcined and crushed.

VI. — A METHOD OF FACILITATING PHOTOGRAPHY OF FOSSILS, BY GILBERT VAN INGEN.

A SIMPLE apparatus has been devised by which a fossil of any size can be coated with a thin, opaque, white film which effectually illuminates under the influence of both colour and reflected light. The necessary articles for construction of the apparatus are: a foot-blower, large wide-mouthed bottle of gallon capacity, with three-holed rubber stopper, two bottles of quart capacity, each with two-holed rubber stopper, glass tubing of one-eighth-inch bore and rubber tubing to fit same (three feet of each), two U-shaped calcium chloride tubes filled with chloride, strong ammonia water, strong HCl. To use: Air from the foot-blower is forced into the large bottle, which equalises the pressure, and thence through the ammonia water and HCl into the smaller bottles. The air, mixed with the gases taken up, is passed through the calcium chloride tubes, where the moisture is extracted, and escapes through the two glass tubes held in the hands at a short distance from the object to be coated. The union of the two gases escaping from the tubes forms ammonium chloride, which settles as an exceedingly fine powder upon the surface of the specimens. The coating thus obtained, when deposited slowly, is of a dead white, which effectually hides all coloration of the surface, and, instead of obliterating the finer modelling, renders the details of the topography with the utmost distinctness. Some surfaces take the coating more readily than others. Fine-grained black limestones and all other rocks that present a velvety surface take the coating well. Porous rocks are difficult to cover. Specimens which have been handled must be washed with benzene. The coating of the salt is perfectly harmless, and may readily be removed by water, gentle heating, or the use of a soft brush. Photographs of such coated specimens fulfil more nearly the requirements of the work than do those taken by the ordinary methods. The coating is also of great assistance in the elucidation of the details of small species, as was found to advantage while studying the lobation of the heads of small trilobites.—*Annals N.Y. Acad. Sci.*, xiv, pp. 115, 116; March, 1902.

REVIEWS.

I.—ANNUAL REPORTS OF THE GEOLOGICAL COMMISSION OF THE CAPE OF GOOD HOPE FOR THE YEARS 1901 AND 1902.

THESE two volumes, issued by the Department of Agriculture of the Cape of Good Hope, reach the same standard of excellence as previous publications, both with respect to the style in which they are presented and the important and interesting matter they contain.

Since the last Report the Scientific staff has undergone some change. Dr. G. S. Corstorphine retired from the Directorship in 1901, and was succeeded by Mr. A. W. Rogers under the title of

Acting Geologist, with a field staff consisting of Messrs. E. H. L. Schwarz and Alex. L. du Toit; while Miss M. Wilman acts as Museum Assistant.

The field work for the two years embraced by the Reports chiefly lay among rocks ranging in age from the Karroo formation upwards, the older rocks forming in proportion only a small amount of the area examined. The account of the Karroo beds, with their numerous and peculiar reptilian remains, and the great extent of the volcanic and igneous activity displayed, affords interesting reading. Very suggestive, too, are the remarks by Mr. Schwarz on the lavas of the Drakensberg and on the line of volcanoes trending parallel with the eastern coast, implying a line of weakness and an axis of folding in this direction. He naturally concludes that the shelving sea-shores at present existing off the southern coast may be explained by the gradual sinking of the sea-bottom without rupture, and that there is no necessity to invoke the aid of great faults.

The Cretaceous rocks and Superficial Deposits are carefully and fully described, while questions of economic importance receive due attention. A petrological account of the Rocks of Matatiele, by Mr. Schwarz, accompanies the Report for 1902, and the geological maps of parts of the Division of Matatiele and of the Igneous Rocks of Kentani, though somewhat roughly reproduced, will be found a distinct addition to the Reports.

It is a matter for congratulation that the fossils collected since the commencement of the Survey are in the hands of specialists, and that the descriptions are to be published in a special volume of the Annals of the South African Museum. We hope that good figures will accompany the descriptions.

The Report for 1901 contains an account of a journey from Swellendam to Mount Bay; a general survey of the rocks in the southern part of the Transkei and Pondoland, including a description of the Cretaceous rocks of Eastern Pondoland; and a Geological Survey of the Division of Kentani. The work, owing to the war. had to be carried on in the native reservation, instead of being continued in the Western Provinces, and this somewhat breaks the thread of previous Reports. The results obtained are, however, of considerable interest. The account of the igneous intrusions in Pondoland deserves especial attention, more particularly the following passage:—"Along the banks of the Great Kei River, north of the Bridge, there are some very fine examples of the laccolitic form of intrusion of the dolerite, but what strikes one at once is that the sedimentary rocks do not seem to have been arched up over the dome-shaped masses of igneous rocks; the contacts are not well shown, but it certainly looks as if the strata had disappeared in the space occupied by the igneous rocks, and the ends of the beds seem to abut against the rounded contours of the dolerite, a fact which we again and again noticed throughout the Territories, and which was beautifully shown in the sections of actual contacts along the Kentani coast."

Among other points of interest we may notice the description of the richly fossiliferous Cretaceous rocks (Umtamvuna Beds of Mr. Dunn's map, Izinhluzabalungu deposits of Griesbach); and the field evidence obtained as to the correlation of the Enon Conglomerate and Uitenhage Series.

The Report for 1902 contains an excellent summary of the year's work by Mr. Rogers, which consisted of an examination of the Matatiele Division by Mr. Schwarz, and parts of the Divisions of Beaufort West, Prince Albert, and Sutherland, by Messrs. Rogers and Schwarz. The account of the volcanic rocks of Matatiele by Mr. Schwarz contains much interesting matter, not the least important being the discovery of a whole series of volcanic necks in such positions as indicate that large parts of the Drakensberg and Maluti Ranges were formerly chains of volcanoes, and that they owe their elevation to these causes.

The higher parts of East Griqualand, Mr. Schwarz considers, offer a good field for the search for workable seams of coal, which would probably lie on about the same horizon as those of Indwe.

In the Western Province a nearly complete skeleton of *Pareiasaurus serridens*, weighing 700 lbs., was obtained and sent to Cape Town, where it is to be set up in the Cape Museum. Many other reptilian remains of great interest were also obtained, and the belief is expressed that the Karroo System will be satisfactorily subdivided by their means when they are sufficiently collected and described.

Not the least welcome feature of the Report for 1902 will be the following table of the classification of the Sedimentary Rocks of the Colony, of which we hope Mr. Rogers' anticipation that it will not require any considerable alteration in the near future will be realized:—

			In the Transkei.
SUPERFICIAL DEPOSITS.		Dune sands, and limestone derived from them.	
		Alluvial muds, sands, and gravels near the present levels of the rivers. Laterite.	
		Estuarine deposits containing foraminifera and *Cryptodon globosus*.	
		Quartzitic rocks and ironstone gravels, representing older river deposits and laterites.	
	Pondoland Cretaceous Series.		
	Uitenhage Series.		
KARROO SYSTEM.	STORMBERG SERIES.	Volcanic Beds.	
		Cave Sandstone.	
		Red Beds.	
		Molteno Beds.	
	BEAUFORT SERIES.	Zone of Specialized Theriodonts.	Kentani Beds.
		Dicynodon Beds.	Idutywa Beds.
		Pareiasaurus Beds.	
	ECCA SERIES.	Shales and thin sandstones.	Umsikaba Beds.
		Laingsburg Beds.	
		Shales.	
	DWYKA SERIES.	Upper Shales.	
		Conglomerate.	
		Lower Shales.	

CAPE SYSTEM. { Witteberg Series.
Bokkeveld Series.
Table Mountain Series.

PRE-CAPE ROCKS:—
In the south and west of the Colony—
Ibiquas Series.
Cango Series.
Malmesbury Series.
In the north and north-west of the Colony—
Matsap Series.
Griqua Town Series.
Campbell Rand Series.
'Keis Series.
Namaqualand Schists (?).

The age of the pre-Cape Rocks (Primary of Schenck), among the different members of which two, and probably three, unconformities have been detected, is left an open question; it being only suggested that some of them may eventually prove to be of Lower Palæozoic age. We ourselves have been struck with their many resemblances to the pre-Cambrian rocks of India. The overlying, unconformable Cape System is considered to be probably the equivalent of the Lower Devonian of other countries. The classification of Schenck is adopted for the Karroo System, excepting in the separation of the Dwyka Series from the Ecca Beds. Whether the Uitenhage Series and the Cretaceous Series of Pondoland may be placed together in a Cretaceous System depends upon the results obtained by the palæontologists, who have not definitely settled the age of the Uitenhage fauna and flora. WALCOT GIBSON.

II.—PETROGRAPHISCHES PRAKTIKUM: ZWEITER TEIL: GESTEINE. By Dr. REINHOLD REINISCH. Large 8vo; pp. vii, 180. Berlin, 1904.

THIS is a practical guide to the study of rocks, written by one familiar with teaching. The characters of the several rock-forming minerals having been dealt with in the former part of the work, dated 1901, the author is able to plunge directly into the systematic description of the rocks themselves. About three-fifths of the book is devoted to the eruptive rocks, which are treated under comprehensive heads which we may call families. For each family the author gives a brief notice of the chief component minerals, the structural peculiarities, the more important types included in the family, and a selection of chemical analyses. The rather conventional arrangement is based on that of Zirkel, the principal divisions being characterized by the preponderance of alkali-felspars, of lime-soda-felspars, or of felspathoids, or by the absence of all these minerals. The discarding of the 'dyke-rocks' leads to confusion in some places, as e.g. when minette and vogesite are grouped with the orthophyres, etc. On the other hand, the distinction made in most of the families between the 'Alkali' and the 'Alkalikalk' groups is one which may profitably be impressed on the student. The practical point of view is constantly maintained in the treatment of the rocks; but there are at the end of this section a few pages dealing with petrogenesis and chemical classification, too condensed to be of much service.

The second section, on the sedimentary rocks, is concerned with precipitates (rock-salt, etc.), tuffs, sandstones, sinters, limestones, clays, etc.; while the third is devoted to the crystalline schists, a term used in a rather wide sense to include gneisses, granulites, mica-schists, eclogites, etc.

The work, though not professing to offer original information, will be found a useful handbook of descriptive petrography. It is clearly written; and the illustrations of the micro-structures of rocks, simply designed, are well adapted to their object. The only statement which we have to quarrel with occurs on the title-page, where the publication is post-dated by some two months.

A. H.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 4th, 1903.—Sir Archibald Geikie, D.Sc., F.R.S., Vice-President, in the Chair.

The Secretary announced the presentation, by Sir John Evans, K.C.B., D.C.L., F.R.S., For. Sec. G.S., of a platinotype portrait of himself.

The following communications were read:—

1. "Metamorphism in the Loch Lomond District." By E. Hubert Cunningham-Craig, Esq., M.A., F.G.S.[1]

The area dealt with includes all the Highland rocks on either side of the Loch, as well as the area lying to the eastward, including the Trossachs. Each stage of the progressive metamorphism can be accurately determined, and each process can be studied, as a rule, without confusing its effects with those of another process. The rocks from the Leny Grit Group and the Aberfoil Slate Group show dynamic metamorphism, which increases on a higher stratigraphical horizon—the Beinn-Ledi Group; and at Rudha Mor the beginning of the thermal type is seen. This is quickly superseded by a constructive metamorphism, probably of hydrothermal type, under which, combined with, or preceded by, the increasing dynamic metamorphism, the rocks become more highly crystalline, until all clastic structures are obliterated. The segregation of like minerals into folia, the total recrystallization, and the genesis of new mineral groupings, result finally in the production of coarsely crystalline albite-gneisses from a series of fine and coarse siliceous and felspathic grits. Contact with plutonic igneous masses obliterates many of the results produced by hydrothermal, constructive, metamorphism.

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[1] *Communicated* by permission of the Director of H.M. Geological Survey.

2. "On a New Cave on the Eastern Side of Gibraltar." By Henry Dyke Acland, Esq., F.G.S.

This cave, discovered in 1902, is situated a short distance south of the eastern end of the tunnel, which pierces the Rock from the Dockyard on the western side to 'Monkeys' Quarry' on the eastern. It was opened by blasting operations; and from the opening thus made, 88 feet above sea-level, the floor falls to the west. The main hall is about 70 feet high and 45 feet wide, and has a smooth stalagmite floor resting on breccia and a stalactitic roof covering the limestone of the Rock. Its floor falls to a point 19 feet above sea-level. The lower gallery descends at its far end to little, if anything, short of sea-level. Its floor consists of stalagmite resting on fine calcareous sand; this on coarse sand, followed by rubbly and calcareous grit, which in time rests on the rock-floor of the cave at a depth of 15 feet. In the calcareous grit are numerous well-rounded stones, some pierced by pholades. At a depth of 13 feet were echinids and barnacles. Two other galleries were explored, and in these, as in the lower gallery, the walls are pitted to a height of 28 feet above sea-level. The author concludes that the cave existed at first as a fissure, to which the sea later obtained access through a large entrance for a long period; and during this period the Rock was elevated some 42 feet. The cave was closed to the sea at a period geologically recent; and the breccia and sand-slopes at this point on the eastern side of the Rock, which are 150 feet wide and reach to a height of 200–300 feet above sea-level, date from a still more recent period.

CORRESPONDENCE.

A FINAL WORD ON FLUID INCLUSIONS.

SIR,—I am very sincerely obliged to General McMahon for his full reply to my paper on granite. I can assure him that he is mistaken in supposing my motives to be sinister.

Since the late W. Pengelly, F.R.S., in 1862, read his paper "On the Age of the Dartmoor Granites" (mark the plural), the granite problem has greatly interested local geologists, who, for forty-one years, have fought over the question with equal keenness and good temper.

General McMahon now writes, "My critic's conclusion is irreconcilable with the facts stated in my Belfast address, hence possibly his anxiety to discredit my facts under cover of an attack on the views expressed by me"! Now I never to my knowledge bolstered a theory, or sought to discredit a fact; and, so far from wishing to discredit General McMahon's facts, I should be as pleased to see his theory confirmed as anyone else's, and certainly as well as my own. With regard to my being called upon to defend my position by proving Dr. Sorby's views erroneous, I think Genera McMahon must have had in his mind Dr. Sorby's paper of 1858. My authority as to the significance of deposited chlorides is chiefly his paper of 1876. Dr. Sorby, no doubt, showed that certain fluids are caught up during the consolidation of crystals, and I have confirmed that observation over and over again; but that established fact does not preclude the possibility of the same crystal being subsequently cracked, and a new, and perhaps an entirely different, set of fluids being introduced; and that possibly more than once.

General McMahon, in his reply, furnishes an example of the very statements which have so perplexed me; e.g., "The potential energy of water *held in a fluid state* by pressure must have been great." This was at above red heat. A few lines later we read, "I thought experts would understand that I had water in *a gaseous state* in my mind" (italics mine).

If, as General McMahon points out, Dr. Sorby proved certain inclusions to contain water, or rather salts dissolved in water, his more triumphant diagnosis was liquid carbonic acid; as he has himself observed—"people would scarcely believe that there were such things as fluid cavities in granite, and no one had imagined such a thing as liquid carbonic acid." If anyone convicts me of dissenting from Dr. Sorby's opinion on any subject on which he has all the known facts before him, I will say with the opossum, "Don't shoot, Colonel, I will come down."

I really am very sorry that my recent papers should have vexed either Professor Bonney or General McMahon. The untoward result was quite unforeseen, and shall not occur again.

A. R. HUNT.

TORQUAY, *November* 5, 1903.

OBITUARY.

THE REV. MAXWELL HENRY CLOSE, M.A.,

MEMB. R. I. ACAD., R.D.S., R.G.S.I., F.G.S.

BORN 1822. DIED SEPTEMBER, 1903.

WE regret to announce the death of the Rev. Maxwell Henry Close, Treasurer of the Royal Irish Academy, at his residence, 38, Lower Baggot Street, Dublin. Mr. Close, who had attained the venerable age of 81 years, was, up till a very short time since, daily to be seen at the Academy's house in Dawson Street. With the passing of Mr. Close a familiar figure in Dublin life has disappeared, greatly to the regret of a large circle, who knew and esteemed him for his scholarly attainments and genial personality. The son of the late Mr. Henry S. Close, Newtown Park, county Dublin, Mr. Maxwell Close was born in 1822. At a comparatively early age he entered Dublin University, where he graduated in 1846. He received the Divinity Testimonium, and in 1847 the degree of Master of Arts. In 1847 he took holy orders, becoming a priest the following year, and went to reside in England as curate of All Saints, Northampton, until 1849, when he was inducted Rector of Shangton, *Leicestershire*. *He* resigned this position eight years later, and became curate of Weltham in the same county until 1861. Returning to Ireland, he devoted himself almost entirely to scientific and literary pursuits. In 1867 he was elected a member of the Royal Irish Academy, whose treasurer he became in 1878. A constant attendant at the stated meetings of the Academy, Mr. Close made some notable contributions to its literature, which were published in the Society's "Proceedings." Amongst the articles written by him may be mentioned his "Note on the Moon's Variation and Parallactic Inequality," which appeared in 1891, and was followed in 1901 by a paper on "Hipparchus and the Precession of the Equinoxes," and "Remarks on a Cosmographical Tractate in the Irish Language in the Library of the Royal Irish Academy." In addition he published a small work on astronomy, of which he was a keen student. He was a member of the Committee of Polite Literature of the Academy, and also a member of the Council, while his connection with the Royal Dublin Society goes back to an early date. He became a Fellow of the Geological Society of London in 1874. He was a leading member of the Royal Geological Society of Ireland, Dublin, and served as President of that body in 1878, when the first meeting of the Society was held in connection with the Royal Dublin Society. He was a contributor to the GEOLOGICAL MAGAZINE for a number of years.—Principally taken from the *Dublin Evening Mail*, Sept. 15, 1903.

The following is a list of scientific papers by the Rev. Maxwell H. Close:—

1.—"On some Striated Surfaces in the Granite near Dublin" [1863]: Dublin Geol. Soc. Journ., vol. x (1864), pp. 96–103.
2.—"Notes on the general Glaciation of the Rocks in the Neighbourhood of Dublin" [1864]: Ireland Geol. Soc. Journ., vol. i (1867), pp. 3–12.
3.—"Notes on the general Glaciation of Ireland" [1866]: Ireland Geol. Soc. Journ., vol. i (1867), pp. 207–242; GEOL. MAG., Vol. IV (1867), pp. 234–235.
4.—"On some Peculiarities in the Phenomena of Glaciation as indicating the Nature of the Agent" [1866]: Ireland Geol. Soc. Journ., vol. i (1867), pp. 287–288.
5.—"Archdeacon Pratt on M. Delaunay's Experiments on the Internal Fluidity of the Earth": GEOL. MAG., Vol. VII (1870), p. 537.
6.—"On some Corries and their Rock-basins in Kerry" [1870]: Ireland Geol. Soc. Journ., vol. ii (1871), pp. 236–249.
7.—"The elevated Shell-bearing Gravels near Dublin" [1873]: GEOL. MAG., Dec. II, Vol. I (1874), pp. 193–197; Ireland Geol. Soc. Journ., vol. iv (1877), pp. 36–40.
8.—"Concerning the Extent of Geological Time": Brit. Assoc. Rep. (1878), p. 548; GEOL. MAG., Dec. II, Vol. V (1878), pp. 450–455.
9.—"The Physical Geology of the Neighbourhood of Dublin": Dublin Soc. Sci. Proc., vol. i (1878), pp. 133–161; Ireland Geol. Soc. Journ., vol. v (1880), pp. 49–77.
10.—Anniversary Address to the Royal Geological Society of Ireland [Feb. 18, 1878]: Dublin Soc. Sci. Proc., vol. ii (1880), pp. 5–24; Ireland Geol. Soc. Journ., vol. v (1880), pp. 1–20.
11.—Anniversary Address to the Royal Geological Society of Ireland [Feb. 17, 1879]: Dublin Soc. Sci. Proc., vol. ii (1880), pp. 191–208; Ireland Geol. Soc. Journ., vol. v (1880), pp. 132–149.
12.—"On the Definition of Force as the Cause of Motion, with some of the inconveniences connected therewith" [1882]: Dublin Soc. Sci. Proc., vol. iii (1883), pp. 336–343.
13.—"On the meaning of 'Force'": Phil. Mag., vol. xv (1883), pp. 248–251.

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ABB

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This page not only completes the volume for 1903, but ends the fourth Decade of the Geological Magazine.

We hope in the January Number, 1904, Vol. I, Decade V, to give a brief retrospect of the past forty years of its existence.

The Editor.

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